THE EFFECT OF REPEATED STATIC LOADING ON THE STRESSES IN THE INCOMPLETELY DEVELOPED TENSION FIELD BEAM

A THESIS

Presented to

The Faculty of the Graduate Division

by

Charles McSween Blackmon

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Aerospace Engineering

Georgia Institute of Technology

June, 1963

In presenting the dissertation as a partial fulfillment of the requirements for an advanced degree from the Georgia Institute of Technology, I agree that the Library of the Institution shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to copy from, or to publish from, this dissertation may be granted by the professor under whose direction it was written, or, in his absence, by the dean of the Graduate Division when such copying or publication is solely for scholarly purposes and does not involve potential financial gain. It is understood that any copying from, or publication of, this dissertation which involves potential financial gain will not be allowed without written permission.

THE EFFECT OF REPEATED STATIC LOADING ON THE STRESSES

IN THE INCOMPLETELY DEVELOPED TENSION FIELD BEAM

Approved:

Date approved by Chairman: May 25, 1963

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Professor George J. Simitses for his suggestion of the topic and his guidance and valuable criticisms during the preparation of this thesis. Gratitude is extended to Professor Donnell W. Dutton and Dr. James T. Wang for their suggestions and for their review of the topic.

TABLE OF CONTENTS

		Page
ACKNOWLEDGMENTS		ii
LIST OF TABLES		iv
LIST OF FIGURES		v
LIST OF SYMBOLS		vi
SUMMARY		vii
Chapter		
I.	INTRODUCTION	1
II.	INSTRUMENTATION AND EQUIPMENT	3
III.	PROCEDURE	6
IV.	TEST HISTORY	10
V.	DISCUSSION OF RESULTS	12
VI.	CONCLUSIONS	17
VII.	RECOMMENDATIONS	18
APPENDIX		19
BIBLIOGRAPHY		77

LIST OF TABLES

Table		Page
1.	Strain in Vertical Stiffener	23
2.	Experimental Stresses for Run 1	24
3.	Experimental Stresses for Run 2	26
4.	Experimental Stresses for Run 3	28
5.	Experimental Stresses for Run 4	30
6.	Experimental Stresses for Run 5	32
7.	Experimental Stresses for Run 6	34
8.	Experimental Stresses for Run 7	36
9.	Experimental Stresses for Run 8	38
10.	Experimental Stresses for Run 9	40
11.	Experimental Stresses for Run 10	42
12.	Experimental Stresses for Run 11	44
13.	Experimental Stresses for Run 12	46
14.	Experimental Stresses for Run 13	48
15.	Experimental Stresses for Run 14	50
16.	Experimental Stresses for Run 15	52
17.	Experimental Stresses for Run 16	54
18.	Experimental Stresses for Run 17	56
19.	Experimental Stresses for Run 18	58

LIST OF FIGURES

Figure		Page
1.	Test Beam	60
2.	Diagram of Test Beam	61
3.	Location of Strain gages	62
4.	Entire Testing Apparatus	63
5.	Web Buckles	64
6.	Stresses versus Cycles for 1000 pound Load	65
7.	Stresses versus Cycles for 2000 pound Load	66
8.	Stresses versus Cycles for 4000 pound Load	67
9.	Stresses versus Cycles for 6000 pound Load	68
10.	Stresses versus Cycles for 8000 pound Load	69
11.	Angle of Principal Stress versus Cycle	70
12.	Maximum Normal Stress (Tensile) versus Applied Shearing Stress	71
13.	Minimum Normal Stress (Compression)versus Applied Shearing Stress	72
14.	Component of Normal Stress in X-Direction versus Applied Shearing Stress	73
15.	Component of Normal Stress in Y-Direction versus Applied Shearing Stress	74
16.	Web Shearing Stress versus Applied Shearing Stress	75
17.	Angle of Principal Stress versus Applied Shearing Stress	76

LIST OF SYMBOLS

b	Horizontal width of web, inches.
E	Young's modulus, pounds per square inch.
E_s	Secant modulus, pounds per square inch.
E_w	Young's modulus of the web, pounds per square inch.
f_s	Applied shearing stress, pounds per square inch.
$f_{s_{cr}}$	Critical buckling stress of web, pounds per square inch.
k_s	Edge fixity factor.
k	Diagonal tension factor.
t	Web thickness, inches.
V	Applied shear, pounds.
β	Ratio of applied shearing stress to critical web buckling stress, dimensionless.
ϵ_1	Maximum principal strain.
ϵ_2	Minimum principal strain.
μ	Poisson's ratio for elastic material, dimensionless.
ν	Variable Poisson's ratio, dimensionless.
σ_i	Equivalent uniaxial stress, pounds per square inch.
σ_x	Stress in x-direction, pounds per square inch.
σ_y	Stress in y-direction, pounds per square inch.
$\sigma_{0.7}$	Stress defined by secant line of slope 0.7E, pounds per square inch.
σ_1	Maximum normal stress (tensile), pounds per square inch.
σ_2	Minimum normal stress (compressive), pounds per square inch.
τ_{xy}	Shearing stress, pounds per square inch.
ϕ_p	Angle of diagonal tension.

SUMMARY

The purpose of this project is to determine what effect repeated static loadings have on the stresses in the incompletely developed tension field beam.

A beam was constructed for this test and strain gages were bonded to the web and vertical stiffeners. The loading was applied in a repeated loading technique using semi-automatic hydraulic equipment.

The stresses were in the plastic range and were analyzed using a method developed by C. S. Ades. The Burroughs 220 Algebraic Compiler was utilized in the reduction of the data taken during these experiments.

The most important results are:

(1) There is a definite change in the stresses with the number of cycles completed,

(2) the critical buckling load is decreased with an increase in the number of cycles,

(3) the life of the web could not be predicted from the experimental data obtained,

(4) there is a variation in the stress distribution over the web which is dependent on the load applied but not on the cycles completed, and

(5) after an initial decrease in the angle of diagonal tension there was no effect on the angle with a further increase in the cycles.

CHAPTER I

INTRODUCTION

The incompletely developed tension field beam, or semi-tension field beam as it is more commonly known, has been the object of many studies during the past thirty years. The basic theory of the pure tension field beam as developed by Wagner (1) * in 1931 and a semi-empirical solution for the semi-tension field beam was advanced by Paul Kuhn (2) in 1952. The analysis made by Kuhn was based on the work of Wagner and an extensive program of tests undertaken at the Langley Aeronautical Laboratory. However, only one of his tests was of the repeated loading technique and it is not known whether or not his resulting equations are valid for the repeated loads.

During the life span of the present day aircraft, it is subjected to tremendous loads which are repeated each time the aircraft takes off or lands. Since semi-tension field beams are an integral part of an aircraft structure, the limitations which should be placed on the existing theories when designing the aircraft for these repeated static loadings should be known.

The purpose of this report is to determine what effect repeated static loadings have on the stresses in the incompletely developed tension field beam.

Only one reference could be found in which an attempt at the

---

*Numbers in parentheses following names refer to items in the Bibliography.

repeated loading technique was tried and this was by Kuhn (2). It should be mentioned that this test was made only by accident and the results were not concisely stated. The only result given was that the beam failed below expected values. Undoubtedly, aircraft companies have performed similar tests but no results have been published.

CHAPTER II

INSTRUMENTATION AND EQUIPMENT

Test Beam

For the incompletely developed tension field beam tests a beam similar to that used by Kuhn (2) in his NACA investigations was constructed. The beam was cantilevered from a rigid backup structure as shown in Figure 1. Vertical stiffeners, with the exception of the end stiffeners, were made of two 1/8 by 7/8 by 7/8 7075-T6 extrusions placed back to back on each side of the web. The end stiffeners were made from two 1/8 by 1 by 1 steel angles placed back to back. Flanges were made from 1/16 by 7/8 by 1 2024-T6 bulb extrusions and separated from the web by 1/8 by 1 filler strips placed back to back on the web. The flanges were capped by 3/8 by 2 3/8 2024-T6 aluminum bar stock. The web is made from 7075-T6 clad aluminum plate and its nominal thickness is .040 inches. The grain was placed so as to run horizontally. The basic dimensions of the beam are shown in Figure 2.

The beam was attached to the mounting plate at the top and bottom by 5/16 by 2 1/2 by 2 1/2 steel angles. However, after the twenty-fifth cycle it was necessary to increase the size of the bottom angle to 1/2 by 3 by 3 in order to prevent failure of this angle. The mounting plate is made of 5/16 inch steel plate and is attached to the backup structure with 5/8 inch steel machine bolts.

Strain Gage System

All tests were made using standard SR-4 type electric strain gages manufactured by the Baldwin-Lima-Hamilton Corporation. The strain gage rosettes were of the AR4-1 model and the axial gages were of the A-12 model. The location of the rosettes can be seen in Figures 2 and 3. The axial gages were centered on the outstanding leg of the vertical stiffeners on either side of the instrumented panel.

A Baldwin-Lima-Hamilton Type N portable strain indicator was used to measure the strains in the structure by indicating the change in electrical resistance in SR-4 bonded wire strain gages.

To measure the strains on the web two gages, bonded in identical positions on opposite sides of the web, were connected in series. These gages were connected in series in order to cancel bending effects (mid-plane strains were obtained this way). These gages, along with two series connected temperature compensating gages, were then connected into a Baldwin-Lima-Hamilton Type 525 switching and balancing unit. The axial gages, along with a temperature compensating gage were also connected to the switching unit. Twenty-four channels were required so three switching and balancing units were wired in parallel and the output from these units was wired into the strain indicator. These units can be seen on the table in Figure 4.

Loading Apparatus

To load the beam a hydraulic jack, EnerPac model RC 156 with a loading capacity of ten tons, was used and the hydraulic pressure for this jack was supplied by two sources. In order to obtain the number of cycles required with the maximum efficiency possible an EnerPac model

PA 600 electric hydraulic pump equipped with an electric valve and control box for remote operation was used. The valve design allows indefinite load holding capacity, with motor idling. This pump was also equipped with a throttling valve in order to control the speed at which the load was applied. An EnerPac model P 39 manual pump equipped with a standard hydraulic gage calibrated in two hundred pound increments was used to take incremental readings when loading the beam.

CHAPTER III

PROCEDURE

In order to obtain the repeated loads that were needed with a sufficient amount of speed in loading a semi-automatic hydraulic system was used. Also, since the loading ratio, f_s/f_{scr}, involved in loading this beam is large and the stresses are in the plastic range a method was needed to reduce the strain gage data. Both these procedures will be discussed in this chapter.

Testing Procedure

Since this was to be a repeated loading test, special care was taken to insure against any scratches or cuts on the faces of the web. The imperfections could possibly cause a premature failure of the web.

The strain gages were mounted with SR-4 cement, the rosettes being placed on the web and the axial gages on the vertical stiffeners. Ample time, a minimum of 24 hours in all cases, was allowed for the gages to cure before applying any load whatever. The lead wires from the gages were carefully soldered to small flexible wires which were attached to the cables connected to the switching and balancing units. After installation all gages were checked for continuity and also for gage to ground resistance. After all gages were working perfectly they were sealed with a layer of petrosene wax to insure moisture stability.

The beam was then cantilevered on the backup structure and the loads were applied through the saddle arrangement shown in Figure 1. The upper limit of load applied was that load which would produce an easily detectable set in the web. This was taken to between ten and eleven times the critical buckling load and was determined to be approximately 8,000 pounds.

The electric hydraulic pump could be used to deliver any load desired up to 10,000 pounds per square inch. The jack used was placed between the heads of a Riehle universal test machine and the bypass valve on the pump calibrated to deliver a maximum indicated load of 8,000 pounds. Thus, by activating the load switch on the pump the load could be varied from zero to a maximum of 8,000 pounds, enabling the operator to load the beam consistently to 8,000 pounds.

Method of Loading

The repeated loadings are made using a combination of the electric hydraulic pump and a manually operated pump. The electric pump was attached to the jack and the load was applied to the beam. In order not to have dynamic effects enter the calculations a throttling valve was attached to the electric pump. This was done in order to slow the flow of oil so the application of the load would not be sudden. After the load was applied the beam was allowed to stabilize. The load was then released gradually and again the beam was allowed to stabilize before the loading procedure was initiated again. This procedure was accomplished in approximately one minute and was repeated until the operator felt, through monitoring several strain gages, a significant change had occurred. The entire system of strain gages was then read and recorded.

Strain Gage Readings

In order to record strains, the electric pump was disconnected from the jack, the manual pump was attached, and the loads were then applied in increments. Readings were taken at the zero load and after each increment, as indicated by the gage on the pump, of the load had been applied and the loading system had stabilized. After the maximum load had been applied and released another zero reading was taken. The electric pump was again placed in operation and the loading procedure repeated.

Reduction of Data

A method was needed which would accomplish the reduction of strain rosettes in the plastic range with speed and accuracy. If permanent strains are present, the reduction of the principal strains to principal stresses assuming perfectly elastic condition can be much in error. A paper by Ades (5) gives equations for the principal stresses which can be used when either elastic or plastic strains are present.

In order to use these equations it is first necessary to obtain the principal strains. The rosettes used on the beam web were all of the delta type and the equations for the principal strains can be found in Perry and Lissner (4).

For a biaxial-stress condition, the principal stresses in terms of the principal strains are:

$$\sigma_1 = \frac{E_s}{1-\nu^2}(\epsilon_1 + \nu\epsilon_2)$$

$$\sigma_2 = \frac{E_s}{1-\nu^2}(\epsilon_2 + \nu\epsilon_1)$$

Where ν is a variable Poisson's ratio.

$$\nu = \frac{1}{2} - \frac{E_s}{2E}(1-2\mu)$$

The value of E_s is dependent on the degree of plasticity. The value of E_s can be determined from the uniaxial stress-strain curve in accordance with the following value of the equivalent uniaxial stress.

$$\sigma_i = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2}$$

This theory is based on the following assumptions: (1) the material is isotropic, (2) the strains are small, (3) the directions of the principal stresses do not change appreciably, and (4) the ratio of the principal stresses remains the same. With the possible exception of (4) all these assumptions are satisfied.

If the stress-strain curve can be represented by the Ramberg-Osgood equation E_s can be determined as follows:

$$E_s = \frac{E}{1+\frac{3}{7}\left(\frac{\sigma_i}{\sigma_{0.7}}\right)^{n-1}}$$

These equations must be solved simultaneously in order to determine the values of σ_1 and σ_2.

The high speed digital computer was used to reduce the data recorded during these tests. A program was written for the Burroughs 220 Algebraic Compiler which would take the raw strain data and convert it into the principal strains and their direction. It would then compute the principal elastic and plastic stresses. The principal plastic stresses were then converted into rectangular components. This program appears in the appendix.

CHAPTER IV

TEST HISTORY

This section is a brief description of the events that took place during the test phase and it is important to the continuity of this report.

All strain gages were applied using SR-4 cement and were working properly when the testing began. Gage readings were taken on the first cycle but the accuracy of these readings is somewhat doubtful at high values of the load.

Between the first and twenty-fifth cycles there was a noticeable amount of creaking in the beam as it was being loaded. At the end of the twenty-fifth cycle the bottom attachment was failing and had to be replaced with a heavier angle. All strain gages were working properly at this time and it was noted that a permanent set had developed in the web.

At the end of the seventy-fifth cycle it was noted that leg two of gage six and leg one of gage two had failed. However, some data were obtained from gage two. After replacing the attachment angle no more unusual noises were heard. It seemed at this time that the web had stretched even more. At the end of the one hundred fiftieth cycle gage six was replaced and by resoldering the leads gage two was repaired.

The testing was continued and when strain readings were taken at the end of the two hundredth cycle it was found that gage six had failed once more. It seemed at this point that the strains were beginning to rise so it was decided to take readings at smaller intervals. Thus, strains were taken again at the end of the two hundred tenth cycle. Gage six was replaced again at the beginning of the two hundred first cycle. Readings were also taken at the end of the two hundred fortieth cycle and the strains appeared to have reached a constant value.

Strain readings were taken again at the two hundred seventy-fifth cycle at which time it was noted that gage six had failed again. This gage was examined closely and it appeared that the weld between the gage lead wire and the wire grid had failed. This is attributed to the gage being in a region of severe buckling. This gage was not replaced again.

During the eight hundred fortieth cycle a small crack was noticed in the flange in the region immediately over the bottom attachment angle. This crack became longer as the number of cycles increased. The testing was completed at the end of the thousandth cycle as at this point enough data had been obtained.

During the entire test it was noticed that when the web buckled the buckles began in the upper left corner of the web. The next buckles to form started from the lower right corner of the web. These buckles can be seen in Figure 5. Due to the difficulty in photographing these buckles they can only be seen in the panel on the right of the instrumented panel although all panels had buckled.

CHAPTER V

DISCUSSION OF RESULTS

In order to compare the experimental results obtained in these tests with theoretical values of stresses and angle of diagonal tension, these quantities were calculated using the standard theories available now. These two methods are the Wagner (1) and Kuhn (2) theories. A brief description of the procedure and the equations used are given here.

Accepted Theories

Kuhn Analysis

In Kuhn's analysis of semi-tension field beams, it is assumed that part of the shear load kV is resisted by pure tension field action and that the remaining load (1 - k)V is resisted by the beam acting as a shear-resistant beam. From theoretical and experimental data, it has been found that the tension field factor, k, is given by the expression:

$$k = \tanh\left(\frac{1}{2}\log_{10}\frac{f_s}{f_{s_{cr}}}\right)$$

Thus, the stresses in the web may be obtained by multiplying the values for a shear resistant web by (1 - k) and those for a pure tension field beam by k and then superimposing them. The following relations are then obtained:

$$\sigma_x = kf_s \cot\phi_P$$

$$\sigma_Y = kf_s \tan\phi_P$$

$$\sigma_2 = -(1-k)\, f_s$$

$$\sigma_1 = (1-k)f_s + \frac{2kf_s}{\sin 2\phi_P}$$

Wagner Theory

Wagner's theory was modified to assume that the critical buckling stress is not negligibly small and furthermore σ_2 remains constant after buckling. The value of σ_2 is given by the equation:

$$\sigma_2 \approx f_{s_{cr}} = -k_s E_w \left(\frac{t}{b}\right)^2$$

The following relations are then obtained.

$$\sigma_x = f_s(\cot\phi_p - \beta)$$

$$\sigma_y = f_s(\tan\phi_p - \beta)$$

$$\sigma_1 = f_s(2\csc 2\phi_p - \beta)$$

Where β is defined as $\frac{f_{s_{cr}}}{f_s}$.

Buckling Load

The buckling of the web was determined by the appearance of a significant change in the strains in the vertical stiffeners. Theoretically, for a pure shear resistant beam there will be no stresses, and consequently no strains, in the vertical stiffeners; however, after the web has buckled and the beam is in the semi-tension class stresses will appear in the vertical stiffeners. From Table 1 it appeared that the critical buckling load decreases with an increase in cycles. A significant change occurs in the strain in the vertical stiffeners around 1,000 pound applied load thus indicating that the web has buckled. However, after the one hundred twenty-fifth cycle this change occurred at approximately 800 pounds of applied load. This seems indicative of a lowering of the buckling load with an increase in the number of cycles.

Web Stresses

Variation with Cycles

From Figure 6 through 10, in which the various stresses are plotted versus cycles, the effect of the increase in number of cycles on the stresses can be seen. From these figures it appears that, in general, the behavior of stresses is erratic during the lower range of cycles, i. e., from 0 to 300 cycles. However, after this erratic behavior the stresses increase slightly and then become very nearly constant.

It was hoped that it would be possible to predict the life of the web from these figures. However, it was not the web which was critical, but rather the method of attaching the beam to its support. Since the stress had become almost constant at 1000 cycles the life of the web could not be predicted from the experimental data obtained.

In Figure 12 through 16 the various center gage stresses σ_1, σ_2, σ_x, σ_Y, and τ_{xY} were plotted for specific cycles versus the applied shearing stress. The cycles selected, which were picked as representative of the entire test phase to be analyzed were the twenty-fifth, two hundred seventy-fifth, and eight hundredth cycles.

In examining Figures 12 through 16 no definite conclusion can be reached as regards the stresses from the two hundred seventy-fifth and twenty-fifth cycles since in some cases the twenty-fifth cycle stresses are greater and in others the two hundred seventy-fifth cycle stresses are greater. But one should not dismiss this evidence as unimportant even though no definite conclusion can be reached. However, it is definitely a general trend for the stresses produced by the eight hundredth cycle to be higher than either the two hundred seventy-fifth or twenty-fifth cycle. These figures are important in that they show a definite change in the stresses with the number of cycles completed.

A close examination of Figure 12 shows that the eight hundredth cycle experimental σ_1 stress is almost identical with the Wagner theory. However, this cannot be stated as a conclusion for all higher cycles since this is an isolated case and more experimentation should be performed. The Kuhn method gives an unconservative answer for the σ_1 stresses. An interpretation of Figure 13 was very difficult. Possibly the only definite observation here is that the Kuhn method gives a fairly good conservative answer for the σ_2 stresses. From the graphs of σ_x and σ_y it is noted that the Wagner theory gives a conservative answer while Kuhn's does not. For the τ_{xy} stress both Kuhn and Wagner give unconservative values.

Variation over the Web Face

Tables 2 through 19 give the stresses for each gage on the web for each cycle recorded. Immediately upon investigation of these tables it is apparent that the stresses are not uniform over the web. This was expected.

A study of the stresses obtained from gage five shows that the stresses at this location reverse direction as the load is increased. This reversal occurs at around 6,000 pounds. This result was obtained in all cycles read thus indicating that the load affects the stress distribution. However, it can be seen that, in general, the stress distribution over the web face for each set of data recorded is the same. Note that the stresses are not the same for each cycle but the distribution is the same.

In finding design allowables for the beam both Kuhn and Wagner used the center gage stresses as an average of the stresses over the web face. It should be noted that in some cases the stresses in some parts of the web are almost four times as great as that indicated by the center gage. This suggests that possibly a new method should be devised in order to account for this variation.

Angle of Diagonal Tension

The variation of angle of diagonal tension, ϕ_p, presented some interesting results. Figure 11 shows that during the first two hundred cycles there is a decrease in angle with an increase in cycles. However, after this initial decrease no further change was indicated with an increase in cycles. The range of ϕ_p is approximately two degrees, with the lowest being identified with the 8,000 pound applied load. From Figure 17 one sees that the curves for experimental ϕ_p follow the general shape as the curve for the Kuhn method. These experimental angles also approach each other as the applied shear increases. This indicates that the angle of diagonal tension at high values of applied load does not vary with the number of cycles.

CHAPTER VI

CONCLUSIONS

It is concluded that:

(1) There is a definite change in the stresses with the number of cycles completed,

(2) there is a lowering of the critical buckling load with an increase in cycles,

(3) the stresses become constant at 1,000 cycles,

(4) the life of the web could not be predicted from the data obtained from these tests,

(5) there is a variation of stresses over the web which is dependent on load applied but not cycles completed, and

(6) after an initial decrease there was no effect on the angle of diagonal tension by an increase in cycles.

CHAPTER VII

RECOMMENDATIONS

The author feels that further tests of this type should be performed with certain modifications. These modifications are:

(1) Different thickness webs should be used,

(2) the load should be applied in both directions, and

(3) different ultimate loading ratios be used for cycling in order to determine a critical loading ratio for a specific number of cycles.

It is recommended that more tests will be done in which a grid of strain gages will be placed over the entire web in order to obtain a clearer picture of the stress distribution in the web. Also, the author suggests that a more comprehensive analytical theory be developed for the tension field beam, possibly of the type as suggested by Denke (3). This theory would eliminate the experimental investigations now needed and also the dependence on the material properties that are now required by Kuhn.

APPENDIX

APPENDIX

Computer Program

```
INTEGER  Run, Cyc,N, Load ( ), GN ( ), EP (,,), I, J, K, M                $
ARRAY    Load (10), GN (4), EP (4,3,10), EPA (4,3,10)                      $
         Mu = 0.33                                                          $
         E = 10.5**6                                                        $
         P = 20                                                             $
         Sig 7 = 0.7**5                                                     $
F..      Read ($$Rundata)                                                   $
INPUT    Rundata(Run, Cyc, N, For I = (1,1,10)$Load(I), For J (1,1,N)      $
         (GN(J), For K = (1,1,3)$ For M = (1,1,10)$ EP(J,K,M)))            $
         Write ($$COLHEAD 1, FMTI)                                          $
OUTPUT   COLHEAD 1(Run, Cyc)                                                $
FORMAT   FMT1(* *, W3, W4, (*Run Number*,I4, B55, I3, * Cycles*, W0))      $
FORMAT   COLHEAD 2(*Gage*, B1, *Load*, B3, *Phi*, B4, *Sigma*, B6,
         *Sigma*, B6, *Sigma*, B4, *Sigma*, B4, *Sigma*, B4, *Sigma*,
         B4, *Tau*, W4, (B1, *No.*, B11, *P*, B9, *Max*, B8, *Min*,
         B8, *1*, B8, *2*, B8, *X*, B8, *Y*, B6. *XY*, W0, (B5, *(LB)*,
         B2, *(Rad.)*, B2, *(Psi)*, B6, *(Psi)*, B6, *(Psi)*, B4, *(Psi)*
         B4, *(Psi)*, B4, *(Psi)*, B4, *(Psi)*, W0)))                       $
         For J = (1,1,N)                                                    $
BEGIN    Write ($$SPACER)                                                   $
FORMAT   SPACER (* *, W0)                                                   $
         For I = (1,1,10)                                                   $
```

```
BEGIN    For K = (1,1,3)                                              $
BEGIN    EPA(J,K,I) = (EP(J,K,I)-((EP(J,K,1)+EP(J,K,10))/2.0))(1**-6) $
                                        END                           $
         A = (EPA(J,1,I)+EPA(J,2,I)+EPA(J,3,I))/3.0                   $
         B = EPA(J,1,I) - A                                           $
         C = (EPA(J,2,I) * EPA (J,3,I))/1.73205                       $
         D = SQRT((B*2.0)+(C*2.0))                                    $
         EMAX = A + D                                                 $
         EMIN = A - D                                                 $
         PHIP = 0.5 ARCTAN (C/B)                                      $
         SIGMAX = E((A/(1.0 - Mu))+(D/(1.0+Mu)))                      $
         SIGMIN = E((A/(1.0 - Mu)) - (D/(1.0+Mu)))                    $
         ES = E                                                       $
G..      Nu = 0.5 - ES(1.0 - 2.0 Mu)/E                                $
         SIG1 = ES(EMAX + NU.EMIN)/(1.0 - (NU*2.0))                   $
         SIG2 = ES(EMIN + NU.EMAX)/(1.0 - (NU*2.0))                   $
         U = ABS (SIG1)                                               $
         V = ABS (SIG2)                                               $
         SIGI = SQRT((U*2.0) + (V*2.0) - SIG1.SIG2)                   $
         ES1 = E/(1.0+0.42857((SIGI/SIG7)*(P - 1)))                   $
         IF  ABS((ES1 - ES)/ES) GTR 0.01                              $
BEGIN    ES = ES1                                                     $
         Go to G                                                      $
                                        END                           $
         SIGX = SIG1(cos(PHIP)*2.0) + SIG2(sin(PHIP)*2.0)             $
         SIGY = SIG1(sin(PHIP)*2.0) + SIG2(cos(PHIP)*2.0)             $
```

```
        TAUXY = 0.5(SIG2 - SIG1)sin(2.0PHIP)                         $
        IF ( I GTR 1 ) and ( I LSS 10)                               $
        Write ($$ANS1,FMT2)                                          $
OUTPUT  ANS1(GN(J),Load(I),PHIP, SIGMAX, SIGMIN,SIG1,SIG2, SIGX,SIGY
        TAUXY)                                                       $
FORMAT  FMT2(13,16,X8.5,X8.0,2X11.0,4X9.0,W0)                        $
                                         END                         $
                                         END                         $
        Go to F                                                      $
        FINISH                                                       $
```

Table 1 Strain in Vertical Stiffener

STRAIN READ IN VERTICAL STIFFNER (MICROINCHES PER INCH)

LOAD	0	300	600	1000	1500	2000	4000	6000	8000	0
CYCLES										
1	13020	13015	13015	13005	12985	12960	12810	12600	12600	13000
25	13025	13020	13015	13010	12985	12965	12850	12740	12620	13035
75	13065	13060	13050	13040	13020	13000	12890	12775	12650	13060
125	13060	13060	13040	13025	13005	12990	12880	12760	12625	13055
200	13060	13045	13035	13020	13000	12975	12850	12720	12575	13050
210	13070	13065	13050	13035	13015	12995	12875	12745	12605	13065
240	13060	13050	13040	13025	13005	12985	12875	12765	12635	13060
275	13055	13050	13040	13030	13010	12985	12880	12745	12625	13050
300	13080	13070	13060	13050	13030	13005	12900	12770	12660	13070
350	13060	13055	13045	13030	13010	12990	12870	12750	12630	13055
425	13085	13075	13070	13050	13030	13010	12885	12750	12605	13080
500	13080	13070	13060	13045	13030	13010	12910	12800	12680	13075
575	13095	13090	13080	13060	13040	13010	12895	12755	12610	13090
650	13085	13070	13060	13045	13025	13000	12880	12750	12600	13080
725	13095	13080	13070	13055	13035	13010	12880	12740	12595	13090
800	13090	13080	13070	13050	13030	13005	12880	12740	12585	13075
900	13075	13070	13060	13040	13020	12990	12870	12730	12585	13070
1000	13070	13060	13050	13030	13010	12980	12850	12705	12565	13065

Table 2 Experimental Stresses for Run 1

RUN NUMBER 1 — 1 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	-.58982	517.	-517.	593.	-593.	226.	-226.	548
1	600	-.72791	1032.	-1032.	1183.	-1183.	135.	-135.	1175
1	1000	-.78133	1513.	-1722.	1771.	-1938.	-68.	-98.	1855
1	1550	.77082	2152.	-2361.	2504.	-2671.	-7.	-158.	-2586
1	2100	.76923	2719.	-2980.	3163.	-3372.	1.	-209.	-3266
1	4100	.77759	5295.	-4824.	5989.	-5614.	278.	96.	-5800
1	6000	.78092	8589.	-6133.	9419.	-7461.	1054.	903.	-8440
1	8100	.77827	8534.	-6235.	9383.	-7550.	1037.	795.	-8466
2	300	.23960	-199.	-792.	-55.	-735.	-94.	-697.	-156
2	600	.73897	369.	-1049.	542.	-1084.	-195.	-346.	-810
2	1000	-.69033	1305.	-1618.	1551.	-1801.	191.	-441.	1646
2	1550	-.62076	2490.	-2229.	2810.	-2601.	979.	-770.	2560
2	2100	-.57836	3805.	-2865.	4199.	-3449.	1913.	-1163.	3501
2	4100	-.49569	9782.	-4924.	10368.	-6493.	6553.	-2678.	7055
2	6000	-.48440	16264.	-7017.	17034.	-9659.	11245.	-3870.	11000
2	8100	-.48383	16305.	-7216.	17109.	-9859.	11273.	-4023.	11105
3	300	-.24661	347.	-86.	352.	-144.	322.	-114.	117
3	600	-.47892	1184.	-348.	1211.	-545.	838.	-172.	718
3	1000	-.53790	2324.	-861.	2409.	-1242.	1450.	-284.	1607
3	1550	-.57061	3636.	-1703.	3831.	-2290.	2045.	-503.	2782
3	2100	-.57859	5068.	-2821.	5418.	-3627.	2713.	-922.	4141
3	4100	-.59527	11214.	-7610.	12229.	-9354.	5442.	-2567.	10020
3	6000	-.60670	18659.	-11920.	20217.	-14842.	8820.	-3445.	16422
3	8100	-.60745	18744.	-12109.	20333.	-15042.	8808.	-3516.	16579

Table 2 (Continued) Experimental Stresses for Run 1

RUN NUMBER 1 — 1 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.32560	-119.	-533.	-23.	-497.	-71.	-448.	143
4	600	-.63469	710.	-840.	837.	-941.	211.	-316.	849
4	1000	-.68476	1873.	-1220.	2033.	-1513.	614.	-94.	1737
4	1550	-.69557	3472.	-1461.	3630.	-2026.	1307.	296.	2782
4	2100	-.69518	5423.	-1688.	5566.	-2587.	2221.	757.	4010
4	4100	-.69516	13786.	-2267.	13797.	-4609.	6245.	2941.	9054
4	6000	-.69225	24184.	-2740.	23987.	-6883.	11410.	5693.	15168
4	8100	-.69224	24384.	-2679.	24171.	-6859.	11530.	5782.	15246
5	300	-.62170	-282.	-1101.	-82.	-1021.	-401.	-702.	444
5	600	-.76262	200.	-1532.	462.	-1525.	-485.	-576.	992
5	1000	-.66683	-206.	-2222.	187.	-2124.	-697.	-1240.	1123
5	1550	.77004	1607.	-2678.	2030.	-2884.	-351.	-502.	-2456
5	2100	.76936	2624.	-3121.	3096.	-3492.	-92.	-303.	-3292
5	4100	-.76594	7930.	-4248.	8450.	-5513.	1740.	1197.	6976
5	6000	-.73558	15004.	-5105.	15476.	-7580.	5094.	2801.	11471
5	8100	-.73421	15200.	-5144.	15673.	-7652.	5202.	2818.	11601
6	300	.69033	-152.	-1754.	157.	-1678.	-586.	-933.	-901
6	600	.75842	502.	-2670.	954.	-2683.	-766.	-962.	-1816
6	1000	-.77461	1453.	-4039.	2118.	-4180.	-963.	-1099.	3148
6	1550	-.74794	2884.	-5731.	3803.	-6074.	-765.	-1505.	4925
6	2100	-.72791	4828.	-7675.	6032.	-8303.	-313.	-1957.	7120
6	4100	-.71981	14825.	-14851.	17002.	-17023.	2214.	-2235.	16866
6	6000	-.73263	28331.	-21514.	31294.	-25856.	5728.	-290.	28416
6	8100	-.73240	28574.	-21548.	31536.	-25932.	5841.	-237.	28573

Table 3 Experimental Stresses for Run 2

RUN NUMBER 2 — 25 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.61866	-11.	-614.	95.	-595.	-136.	-363.	-326
1	600	.62545	366.	-1097.	547.	-1131.	-27.	-555.	-796
1	1000	.62493	640.	-1737.	925.	-1800.	-7.	-867.	-1293
1	1500	.65265	1177.	-2483.	1577.	-2619.	29.	-1071.	-2025
1	2000	.67332	1599.	-2958.	2071.	-3154.	39.	-1122.	-2547
1	4000	.71082	3683.	-4728.	4405.	-5238.	299.	-1133.	-4768
1	6000	.73463	5646.	-5646.	6474.	-6474.	656.	-656.	-6441
1	8000	.76469	7934.	-6367.	8823.	-7573.	964.	285.	-8191
2	300	-.38802	748.	-357.	790.	-477.	608.	-296.	444
2	600	-.50639	1320.	-667.	1400.	-879.	863.	-343.	966
2	1000	-.54170	1952.	-1194.	2106.	-1501.	1146.	-542.	1593
2	1500	-.53034	3173.	-1893.	3414.	-2393.	1928.	-907.	2534
2	2000	-.52528	4393.	-2382.	4686.	-3082.	2733.	-1128.	3370
2	4000	-.48102	9302.	-4365.	9804.	-5866.	6449.	-2511.	6428
2	6000	-.48080	12737.	-5658.	13369.	-7723.	8857.	-3211.	8649
2	8000	-.49701	15556.	-7172.	16374.	-9686.	10449.	-3761.	10922
3	300	-.59898	496.	-261.	528.	-341.	252.	-64.	405
3	600	-.56838	1244.	-539.	1303.	-741.	711.	-148.	927
3	1000	-.57959	1960.	-1098.	2097.	-1409.	1045.	-357.	1607
3	1500	-.58434	3230.	-1846.	3462.	-2358.	1691.	-586.	2678
3	2000	-.58782	4344.	-2594.	4675.	-3279.	2229.	-833.	3671
3	4000	-.59070	9395.	-6444.	10257.	-7903.	4624.	-2270.	8400
3	6000	-.60177	13565.	-9412.	14828.	-11516.	6385.	-3073.	12294
3	8000	-.61027	18379.	-11876.	19938.	-14751.	8545.	-3357.	16292

Table 3 (Continued) Experimental Stresses for Run 2

RUN NUMBER 2 25 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.75917	376.	-376.	431.	-431.	22.	-22.	431
4	600	-.75081	1091.	-621.	1169.	-794.	255.	119.	979
4	1000	-.75588	1945.	-953.	2057.	-1266.	493.	297.	1659
4	1500	-.74185	3468.	-1221.	3584.	-1792.	1129.	661.	2678
4	2000	-.73244	4898.	-1450.	5014.	-2264.	1759.	990.	3619
4	4000	-.71289	11837.	-1912.	11840.	-3924.	5097.	2819.	7799
4	6000	-.70547	17666.	-2255.	17566.	-5274.	7963.	4327.	11275
4	8000	-.69555	23923.	-2505.	23692.	-6609.	11249.	5833.	14907
5	300	.63208	161.	-579.	258.	-591.	-38.	-294.	-405
5	600	.64269	541.	-907.	684.	-976.	88.	-379.	-796
5	1000	.64622	990.	-1356.	1199.	-1491.	223.	-515.	-1293
5	1500	.66950	1809.	-1913.	2092.	-2176.	448.	-531.	-2077
5	2000	.68511	2555.	-2398.	2902.	-2777.	628.	-503.	-2782
5	4000	.74929	6922.	-3474.	7335.	-4585.	1804.	945.	-5944
5	6000	-.78137	10719.	-3980.	11114.	-5739.	2755.	2619.	8426
5	8000	-.74279	14966.	-4361.	15309.	-6850.	5172.	3286.	11039
6	300	.00002	119.	-746.	246.	-746.	246.	-746.	-0
6	600	-.76658	578.	-1519.	827.	-1577.	-329.	-420.	1201
6	1000	-.74675	1195.	-2553.	1607.	-2690.	-375.	-707.	2142
6	1500	-.72270	2452.	-4071.	3093.	-4385.	-178.	-1113.	3710
6	2000	-.70948	3618.	-5603.	4495.	-6078.	7.	-1591.	5226
6	4000	-.70573	11401.	-11819.	13145.	-13478.	1945.	-2278.	13143
6	6000	-.71492	19045.	-16172.	21335.	-19043.	3982.	-1690.	19989
6	8000	-.72655	27951.	-20011.	30662.	-24329.	6395.	-61.	27305

Table 4 Experimental Stresses for Run 3

RUN NUMBER 3 — 75 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.56474	198.	-355.	255.	-380.	73.	-198.	-287
1	600	.61470	419.	-837.	554.	-887.	74.	-408.	-679
1	900	.65069	800.	-1374.	1017.	-1476.	102.	-561.	-1201
1	1500	.65275	1266.	-1945.	1570.	-2112.	211.	-753.	-1776
1	2000	.66584	1614.	-2607.	2024.	-2816.	177.	-969.	-2351
1	4000	.71455	3678.	-4148.	4299.	-4674.	446.	-821.	-4442
1	6000	.73352	5721.	-5460.	6514.	-6306.	767.	-559.	-6375
1	8000	.76531	8095.	-6319.	8972.	-7555.	1040.	376.	-8257
2	300	-.40231	840.	-108.	835.	-252.	668.	-85.	391
2	600	-.48601	1302.	-518.	1356.	-731.	900.	-275.	862
2	900	-.50102	2089.	-940.	2195.	-1278.	1393.	-477.	1463
2	1500	-.49887	3193.	-1417.	3351.	-1934.	2141.	-724.	2221
2	2000	-.49825	4298.	-1999.	4526.	-2693.	2877.	-1044.	3031
2	4000	-.42037	10660.	-3347.	10947.	-5113.	8272.	-2438.	5983
2	6000	-.24438	28330.	-3412.	28135.	-8260.	26004.	-6129.	8544
2	8000	-.23473	38004.	-4310.	37695.	-10820.	35071.	-8196.	10974
3	300	-.54057	492.	-179.	509.	-259.	306.	-56.	339
3	600	-.55874	1046.	-576.	1117.	-742.	594.	-219.	836
3	900	-.57391	1840.	-1108.	1982.	-1398.	985.	-402.	1541
3	1500	-.58428	2875.	-1830.	3114.	-2280.	1472.	-639.	2482
3	2000	-.58333	4025.	-2667.	4378.	-3294.	2050.	-966.	3527
3	4000	-.58857	8799.	-6500.	9687.	-7854.	4280.	-2447.	8100
3	6000	-.59450	13779.	-9600.	15069.	-11736.	6660.	-3326.	12437
3	8000	-.59997	19081.	-11924.	20629.	-14920.	9295.	-3587.	16566

Table 4 (Continued) Experimental Stresses for Run 3

RUN NUMBER 3 75 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.73897	524.	-184.	542.	-271.	173.	97.	405
4	600	-.74887	1163.	-458.	1211.	-648.	349.	213.	927
4	900	-.73248	2150.	-714.	2215.	-1069.	746.	399.	1633
4	1500	-.72732	3507.	-921.	3569.	-1507.	1325.	737.	2521
4	2000	-.72408	4985.	-1145.	5046.	-1983.	1961.	1101.	3488
4	4000	-.70704	11756.	-1648.	11716.	-3653.	5230.	2831.	7590
4	6000	-.69795	18333.	-2009.	18172.	-5151.	8539.	4481.	11484
4	8000	-.52082	16434.	-4131.	16696.	-6883.	10857.	-1045.	10177
5	300	.64488	363.	-206.	388.	-263.	153.	-28.	-313
5	600	.64982	664.	-612.	753.	-711.	216.	-175.	-705
5	900	.64772	1165.	-1060.	1317.	-1234.	388.	-305.	-1228
5	1500	.67496	1864.	-1498.	2074.	-1782.	568.	-276.	-1881
5	2000	.70940	2703.	-1815.	2944.	-2236.	746.	-38.	-2560
5	4000	.75156	6693.	-3037.	7036.	-4120.	1835.	1081.	-5565
5	6000	-.77818	11002.	-3584.	11320.	-5404.	3079.	2837.	8361
5	8000	-.74001	15419.	-4031.	15692.	-6609.	5552.	3530.	11105

Table 5 Experimental Stresses for Run 4

RUN NUMBER 4 — 125 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.69033	165.	-530.	253.	-544.	-70.	-221.	-391
1	600	.63604	584.	-845.	716.	-924.	137.	-345.	-783
1	1000	.67191	1168.	-1638.	1421.	-1796.	174.	-549.	-1567
1	1500	.68097	1579.	-2101.	1901.	-2318.	229.	-645.	-2064
1	2000	.68655	1990.	-2565.	2382.	-2840.	283.	-742.	-2560
1	4000	.72466	3887.	-4148.	4502.	-4710.	454.	-662.	-4572
1	6000	.74491	5980.	-5406.	6756.	-6298.	757.	-298.	-6506
1	8000	.77011	8468.	-6169.	9308.	-7475.	1173.	660.	-8387
3	300	-.57589	632.	-240.	656.	-344.	359.	-47.	457
3	600	-.55750	946.	-398.	989.	-552.	558.	-120.	692
3	1000	-.57751	2415.	-1396.	2591.	-1778.	1288.	-476.	1998
3	1500	-.58693	3293.	-2118.	3571.	-2633.	1668.	-730.	2861
3	2000	-.59006	4329.	-2892.	4712.	-3567.	2149.	-1003.	3828
3	4000	-.59197	8826.	-6554.	9723.	-7910.	4232.	-2420.	8165
3	6000	-.59792	13692.	-9696.	15002.	-11814.	6504.	-3316.	12477
3	8000	-.60609	18974.	-12105.	20557.	-15077.	8992.	-3513.	16684

Table 5 (Continued) Experimental Stresses for Run 4

RUN NUMBER 4 125 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.72791	500.	-187.	519.	-269.	170.	79.	391
4	600	.00006	1518.	-578.	1576.	-826.	1576.	-826.	-
4	1000	-.71641	2888.	-746.	2938.	-1229.	1140.	567.	2064
4	1500	-.72586	4141.	-954.	4191.	-1650.	1617.	923.	2900
4	2000	-.72159	5607.	-1010.	5626.	-1960.	2316.	1350.	3762
4	4000	-.70766	11780.	-1645.	11738.	-3655.	5233.	2849.	7603
4	6000	-.69875	18480.	-1972.	18308.	-5141.	8604.	4561.	11549
4	8000	-.69375	25457.	-2263.	25141.	-6641.	12146.	6353.	15625
5	300	.62410	254.	-202.	282.	-240.	103.	-62.	-248
5	600	.64254	703.	-650.	797.	-755.	239.	-197.	-744
5	1000	.66411	1553.	-1240.	1726.	-1476.	509.	-259.	-1554
5	1500	.69144	2224.	-1649.	2450.	-1991.	644.	-185.	-2181
5	2000	.70683	3055.	-1905.	3302.	-2385.	903.	13.	-2808
5	4000	.75396	6827.	-3014.	7163.	-4121.	1875.	1166.	-5631
5	6000	-.77694	11183.	-3609.	11501.	-5459.	3164.	2877.	8479
5	8000	-.74011	15895.	-4036.	16155.	-6697.	5762.	3695.	11379

Table 6 Experimental Stresses for Run 5

RUN NUMBER 5 — 200 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU X (PSI)
1	300	.73994	417.	-887.	560.	-935.	-119.	-255.	-744
1	600	.71455	664.	-1291.	871.	-1371.	-91.	-408.	-1110
1	1000	.70730	1004.	-1787.	1287.	-1912.	-63.	-561.	-1580
1	1500	.71160	1505.	-2341.	1872.	-2539.	-8.	-657.	-2181
1	2000	.71812	1985.	-2821.	2422.	-3088.	36.	-702.	-2730
1	4000	.73630	4075.	-4649.	4772.	-5231.	261.	-719.	-4977
1	6000	.74781	6123.	-5966.	6993.	-6868.	582.	-457.	-6911
1	8000	.77498	8969.	-6827.	9910.	-8201.	1042.	665.	-9054
2	300	-.57836	794.	-873.	924.	-987.	353.	-415.	875
2	600	-.56766	1385.	-1203.	1557.	-1411.	698.	-553.	1345
2	1000	-.54188	2170.	-1569.	2383.	-1904.	1242.	-763.	1894
2	1500	-.52359	3311.	-2135.	3591.	-2654.	2030.	-1092.	2704
2	2000	-.51383	4375.	-2625.	4711.	-3315.	2772.	-1376.	3436
2	4000	-.48424	9319.	-4591.	9860.	-6089.	6403.	-2632.	6571
2	6000	-.47182	13721.	-6121.	14406.	-8344.	9706.	-3644.	9210
2	8000	-.46442	18326.	-7538.	19129.	-10525.	13180.	-4576.	11876
3	300	-.56474	753.	-910.	891.	-1016.	344.	-469.	862
3	600	-.56812	1307.	-1255.	1490.	-1448.	639.	-597.	1332
3	1000	-.57571	2101.	-1840.	2364.	-2155.	1024.	-816.	2064
3	1500	-.57848	3173.	-2651.	3547.	-3130.	1551.	-1134.	3057
3	2000	-.58452	4328.	-3545.	4826.	-4201.	2077.	-1452.	4154
3	4000	-.58720	9614.	-7629.	10677.	-9094.	4608.	-3025.	9119
3	6000	-.59201	14787.	-10608.	16225.	-12891.	7158.	-3824.	13483
3	8000	-.59889	20805.	-12917.	22478.	-16187.	10191.	-3899.	18003

Table 6 (Continued) Experimental Stresses for Run 5

RUN NUMBER 5 — 200 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.72950	956.	-695.	1050.	-842.	209.	-1.	940
4	600	-.72893	1702.	-866.	1805.	-1139.	499.	167.	1463
4	1000	-.71628	2719.	-1100.	2835.	-1543.	947.	344.	2168
4	1500	-.71788	4199.	-1274.	4304.	-1971.	1589.	744.	3109
4	2000	-.71372	5707.	-1476.	5806.	-2431.	2275.	1099.	4076
4	4000	-.70501	13017.	-1943.	12993.	-4160.	5789.	3043.	8466
4	6000	-.69830	19808.	-2360.	19666.	-5750.	9160.	4755.	12516
4	8000	-.69191	27335.	-2678.	27039.	-7372.	13031.	6635.	16906
5	300	.65444	608.	-712.	715.	-799.	154.	-237.	-731
5	600	.65766	937.	-1041.	1092.	-1175.	244.	-328.	-1097
5	1000	.67103	1476.	-1424.	1684.	-1642.	397.	-356.	-1620
5	1500	.69555	2244.	-1878.	2509.	-2217.	568.	-276.	-2325
5	2000	.70709	3143.	-2255.	3449.	-2740.	836.	-128.	-3057
5	4000	.76256	7617.	-3333.	7986.	-4569.	1994.	1421.	-6271
5	6000	-.77224	12050.	-3953.	12404.	-5945.	3470.	2987.	9171
5	8000	-.73459	17140.	-4393.	17428.	-7261.	6335.	3831.	12281

Table 7 Experimental Stresses for Run 6

RUN NUMBER 6 210 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.52359	264.	-708.	381.	-735.	102.	-456.	-483
1	600	.57511	507.	-1265.	714.	-1318.	112.	-716.	-927
1	1000	.64608	1015.	-1615.	1268.	-1747.	175.	-654.	-1450
1	1500	.65426	1395.	-2309.	1759.	-2488.	186.	-915.	-2051
1	2000	.67109	1920.	-2782.	2352.	-3039.	267.	-954.	-2626
1	4000	.71430	3924.	-4525.	4604.	-5083.	446.	-926.	-4794
1	6000	.74063	6156.	-5764.	6990.	-6678.	767.	-454.	-6806
1	8000	.76621	8856.	-6583.	9757.	-7945.	1245.	566.	-8845
2	300	-.58372	674.	-465.	736.	-570.	339.	-173.	600
2	600	-.56679	1265.	-847.	1378.	-1044.	679.	-346.	1097
2	1000	-.54404	2090.	-1254.	2250.	-1584.	1223.	-556.	1698
2	1500	-.52822	3191.	-1729.	3404.	-2237.	1971.	-804.	2456
2	2000	-.51333	4374.	-2284.	4650.	-2984.	2809.	-1142.	3266
2	4000	-.48601	9158.	-4195.	9634.	-5676.	6293.	-2335.	6323
2	6000	-.47324	13716.	-5776.	14341.	-8008.	9698.	-3365.	9067
2	8000	-.46599	18200.	-7178.	18944.	-10153.	13070.	-4278.	11680
3	300	-.61866	660.	-425.	715.	-528.	297.	-109.	587
3	600	-.59482	1291.	-795.	1394.	-998.	642.	-247.	1110
3	1000	-.57976	2080.	-1375.	2262.	-1699.	1073.	-510.	1816
3	1500	-.58590	3194.	-2123.	3475.	-2621.	1611.	-757.	2808
3	2000	-.58655	4386.	-3054.	4796.	-3734.	2183.	-1120.	3932
3	4000	-.58961	9437.	-7008.	10396.	-8459.	4566.	-2629.	8714
3	6000	-.59372	14808.	-10133.	16163.	-12434.	7212.	-3483.	13261
3	8000	-.60075	20671.	-12392.	22256.	-15652.	10143.	-3539.	17677

Table 7 (Continued) Experimental Stresses for Run 6

RUN NUMBER 6 — 210 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.73034	734.	-342.	774.	-461.	224.	88.	614
4	600	-.71917	1555.	-536.	1605.	-793.	564.	247.	1188
4	1000	-.72399	2592.	-737.	2648.	-1169.	973.	505.	1894
4	1500	-.71338	3931.	-927.	3983.	-1587.	1597.	798.	2756
4	2000	-.71589	5578.	-1164.	5625.	-2104.	2295.	1224.	3828
4	4000	-.70424	12596.	-1652.	12533.	-3803.	5684.	3044.	8061
4	6000	-.69549	19693.	-2010.	19494.	-5390.	9277.	4826.	12241
4	8000	-.69062	26946.	-2315.	26598.	-6952.	12983.	6662.	16475
5	300	.58602	496.	-418.	555.	-493.	234.	-172.	-483
5	600	.61866	865.	-943.	1005.	-1068.	308.	-370.	-979
5	1000	.65090	1455.	-1168.	1618.	-1389.	514.	-285.	-1450
5	1500	.67691	2199.	-1651.	2426.	-1988.	693.	-256.	-2155
5	2000	.69700	3090.	-2072.	3365.	-2553.	926.	-114.	-2913
5	4000	.75461	7368.	-3111.	7706.	-4310.	2067.	1328.	-5996
5	6000	-.77325	12019.	-3687.	12327.	-5681.	3541.	3104.	9001
5	8000	-.73510	16908.	-4188.	17166.	-7021.	6287.	3858.	12032
6	300	-.72418	491.	-909.	636.	-969.	-68.	-264.	796
6	600	-.72791	979.	-1658.	1241.	-1783.	-97.	-444.	1502
6	1000	-.71408	1823.	-2711.	2246.	-2954.	15.	-723.	2573
6	1500	-.70932	3045.	-3986.	3656.	-4406.	235.	-985.	3984
6	2000	-.70801	4601.	-5385.	5413.	-6038.	570.	-1195.	5657
6	4000	-.71337	12940.	-10433.	14399.	-12399.	2923.	-923.	13261
6	6000	-.72805	22854.	-14287.	24708.	-17875.	5853.	980.	21152
6	8000	-.74369	33366.	-17015.	35403.	-22361.	8927.	4114.	28782

Table 8 Experimental Stresses for Run 7

RUN NUMBER 7 — 240 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.74646	409.	-435.	474.	-495.	27.	-48.	-483
1	600	.68229	659.	-946.	806.	-1035.	73.	-303.	-901
1	1000	.72187	1154.	-1441.	1373.	-1602.	73.	-303.	-1476
1	1500	.69153	1523.	-2072.	1842.	-2280.	165.	-603.	-2025
1	2000	.70095	1956.	-2505.	2339.	-2776.	211.	-648.	-2521
1	4000	.72057	3748.	-4088.	4357.	-4628.	445.	-716.	-4455
1	6000	.73427	5414.	-5284.	6185.	-6081.	678.	-573.	-6101
1	8000	.75943	7768.	-6175.	8628.	-7358.	1050.	220.	-7982
2	300	-.58514	713.	-400.	763.	-513.	373.	-123.	587
2	600	-.56733	1304.	-782.	1404.	-988.	713.	-297.	1084
2	1000	-.54357	2208.	-1215.	2358.	-1566.	1308.	-516.	1737
2	1500	-.52359	3191.	-1729.	3404.	-2237.	1993.	-827.	2443
2	2000	-.51641	4216.	-2126.	4469.	-2802.	2696.	-1029.	3122
2	4000	-.48864	8523.	-3874.	8962.	-5253.	5829.	-2121.	5892
2	6000	-.47752	12168.	-5168.	12730.	-7147.	8531.	-2948.	8113
2	8000	-.42319	799.	-11769.	2830.	-11580.	399.	-9149.	5395
3	300	-.57558	771.	-327.	806.	-452.	433.	-79.	574
3	600	-.57246	1325.	-776.	1423.	-986.	716.	-279.	1097
3	1000	-.57851	2198.	-1236.	2369.	-1682.	1158.	-470.	1855
3	1500	-.57764	3149.	-2131.	3433.	-2621.	1628.	-815.	2769
3	2000	-.58410	4106.	-2878.	4494.	-3514.	2058.	-1079.	3684
3	4000	-.59086	8645.	-6477.	9534.	-7805.	4153.	-2424.	8021
3	6000	-.59480	12788.	-9210.	14038.	-11184.	6118.	-3264.	11706
3	8000	-.60279	17983.	-11636.	19512.	-14449.	8595.	-3533.	15860

Table 8 (Continued) Experimental Stresses for Run 7

RUN NUMBER 7 — 240 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.71824	827.	-253.	848.	-390.	312.	146.	614
4	600	-.70500	1523.	-531.	1573.	-782.	584.	207.	1162
4	1000	-.71226	2636.	-703.	2685.	-1144.	1049.	491.	1894
4	1500	-.71734	4039.	-905.	4085.	-1585.	1634.	865.	2808
4	2000	-.71347	5426.	-1090.	5465.	-2006.	2264.	1193.	3697
4	4000	-.70640	11528.	-1602.	11486.	-3569.	5142.	2774.	7434
4	6000	-.70208	17449.	-1986.	17308.	-4975.	8014.	4318.	10987
4	8000	-.69508	24091.	-2203.	23803.	-6344.	11437.	6021.	14828
5	300	.64128	491.	-387.	545.	-462.	184.	-101.	-483
5	600	.65850	864.	-760.	972.	-889.	275.	-192.	-901
5	1000	.67043	1455.	-1142.	1614.	-1364.	464.	-214.	-1450
5	1500	.69261	2229.	-1550.	2437.	-1895.	670.	-128.	-2129
5	2000	.70270	2960.	-1915.	3211.	-2378.	876.	-43.	-2756
5	4000	.74929	6739.	-2925.	7061.	-4020.	1920.	1121.	-5526
5	6000	-.78493	10583.	-3478.	10894.	-5227.	2840.	2825.	8061
5	8000	-.74889	15035.	-3908.	15297.	-6422.	5229.	3645.	10830
6	300	-.71372	501.	-788.	624.	-853.	-8.	-220.	731
6	600	-.72492	1034.	-1582.	1281.	-1719.	-37.	-399.	1489
6	1000	-.71722	1970.	-2675.	2382.	-2945.	80.	-643.	2639
6	1500	-.71049	3226.	-3826.	3803.	-4282.	363.	-843.	3997
6	2000	-.70965	4573.	-5017.	5320.	-5675.	652.	-1006.	5435
6	4000	-.71677	11889.	-9460.	13208.	-11270.	2643.	-705.	12124
6	6000	-.72926	20035.	-12852.	21718.	-15989.	4976.	752.	18735
6	8000	-.74239	29577.	-15760.	31501.	-20480.	7743.	3277.	25894

Table 9 Experimental Stresses for Run 8

RUN NUMBER 8 — 275 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.59411	274.	-535.	360.	-568.	69.	-277.	-431
1	600	.60859	505.	-976.	662.	-1037.	106.	-481.	-796
1	1000	.62048	1178.	-1543.	1414.	-1706.	359.	-651.	-1476
1	1500	.65152	1326.	-2005.	1639.	-2181.	234.	-776.	-1842
1	2000	.66798	1728.	-2512.	2119.	-2744.	253.	-878.	-2364
1	4000	.70565	3569.	-4301.	4220.	-4804.	424.	-1008.	-4455
1	6000	.73598	5798.	-5537.	6603.	-6394.	745.	-536.	-6467
1	8000	.75512	7797.	-6335.	8685.	-7518.	1073.	93.	-8087
2	300	-.59974	695.	-356.	738.	-467.	354.	-83.	561
2	600	-.58024	1129.	-685.	1217.	-862.	591.	-237.	953
2	1000	-.54981	1952.	-1090.	2088.	-1401.	1135.	-448.	1554
2	1500	-.53644	2857.	-1577.	3053.	-2032.	1724.	-704.	2234
2	2000	-.52166	3841.	-2039.	4090.	-2653.	2415.	-978.	2913
2	4000	-.48923	8346.	-3932.	8799.	-5278.	5690.	-2169.	5840
2	6000	-.47580	12941.	-5445.	13530.	-7550.	9107.	-3127.	8583
2	8000	-.47093	16625.	-6569.	17307.	-9286.	11832.	-3811.	10752
3	300	-.55728	729.	-285.	759.	-405.	433.	-79.	522
3	600	-.57943	1168.	-672.	1252.	-857.	620.	-224.	966
3	1000	-.59258	1926.	-1221.	2086.	-1523.	960.	-397.	1672
3	1500	-.59742	2805.	-1996.	3075.	-2430.	1333.	-687.	2560
3	2000	-.59986	3805.	-2943.	4213.	-3525.	1746.	-1059.	3605
3	4000	-.60195	8238.	-6801.	9194.	-8048.	3665.	-2519.	8048
3	6000	-.60554	13347.	-9978.	14715.	-12028.	6050.	-3363.	12516
3	8000	-.60923	17821.	-11996.	19416.	-14770.	8221.	-3575.	16043

Table 9 (Continued) Experimental Stresses for Run 8

RUN NUMBER 8 — 275 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.72526	728.	-258.	753.	-378.	255.	119.	561
4	600	-.71464	1304.	-468.	1349.	-682.	476.	190.	1006
4	1000	-.72183	2340.	-669.	2392.	-1058.	885.	447.	1711
4	1500	-.71917	3573.	-909.	3632.	-1507.	1401.	723.	2547
4	2000	-.71982	5053.	-1083.	5101.	-1935.	2043.	1123.	3488
4	4000	-.71063	11568.	-1591.	11523.	-3565.	5103.	2855.	7460
4	6000	-.70252	18527.	-1968.	18353.	-5145.	8542.	4665.	11588
4	8000	-.69676	24573.	-2214.	24273.	-6440.	11624.	6208.	15116
5	300	.64128	491.	-387.	545.	-462.	184.	-101.	-483
5	600	.65551	768.	-716.	872.	-830.	239.	-197.	-823
5	1000	.67244	1308.	-1099.	1464.	-1297.	392.	-225.	-1345
5	1500	.68041	1944.	-1527.	2157.	-1823.	581.	-248.	-1946
5	2000	.70461	2830.	-1995.	3099.	-2433.	778.	-111.	-2730
5	4000	.75200	6685.	-2976.	7018.	-4059.	1848.	1109.	-5526
5	6000	-.78141	11359.	-3523.	11656.	-5406.	3192.	3057.	8531
5	8000	-.75154	15348.	-3907.	15601.	-6476.	5309.	3815.	11013

Table 10 Experimental Stresses for Run 9

RUN NUMBER 9 — 300 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.60816	369.	-578.	459.	-626.	105.	-271.	-509
1	600	.64295	610.	-1028.	772.	-1106.	97.	-430.	-901
1	1000	.65615	999.	-1522.	1237.	-1654.	161.	-577.	-1397
1	1500	.67586	1498.	-2073.	1818.	-2277.	215.	-674.	-1998
1	2000	.67896	1933.	-2612.	2335.	-2877.	279.	-821.	-2547
1	4000	.71189	3709.	-4284.	4353.	-4812.	442.	-900.	-4533
1	6000	.73964	5817.	-5556.	6624.	-6416.	700.	-491.	-6493
1	8000	.75698	7665.	-6464.	8579.	-7621.	939.	19.	-8087
2	300	-.48990	573.	-442.	634.	-530.	376.	-272.	483
2	600	-.51754	1084.	-797.	1193.	-964.	665.	-436.	927
2	1000	-.51282	1912.	-1259.	2078.	-1557.	1203.	-682.	1554
2	1500	-.50190	2977.	-1750.	3200.	-2220.	1945.	-966.	2286
2	2000	-.49991	4003.	-2253.	4284.	-2889.	2636.	-1240.	3018
2	4000	-.47833	8357.	-3995.	8821.	-5342.	5820.	-2341.	5787
2	6000	-.46841	12798.	-5615.	13421.	-7692.	9117.	-3388.	8505
2	8000	-.46376	16290.	-6809.	17023.	-9461.	11724.	-4161.	10595
3	300	-.58514	752.	-360.	794.	-482.	405.	-92.	587
3	600	-.59244	1270.	-722.	1361.	-923.	648.	-211.	1058
3	1000	-.57710	2138.	-1276.	2301.	-1613.	1135.	-448.	1789
3	1500	-.58609	3094.	-2023.	3361.	-2507.	1566.	-711.	2704
3	2000	-.59154	4172.	-2892.	4560.	-3539.	2041.	-1020.	3749
3	4000	-.58994	8663.	-6495.	9555.	-7826.	4176.	-2446.	8035
3	6000	-.59359	13757.	-9761.	15076.	-11889.	6640.	-3452.	12503
3	8000	-.60011	18150.	-11751.	19694.	-14590.	8760.	-3655.	15978

Table 10 (Continued) Experimental Stresses for Run 9

RUN NUMBER 9 — 300 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.72554	851.	-250.	871.	-392.	315.	164.	627
4	600	-.71866	1471.	-505.	1519.	-748.	536.	234.	1123
4	1000	-.72246	2630.	-723.	2683.	-1162.	1001.	519.	1907
4	1500	-.71439	3893.	-941.	3948.	-1594.	1569.	784.	2743
4	2000	-.71472	5449.	-1087.	5487.	-2008.	2267.	1211.	3710
4	4000	-.70632	11549.	-1650.	11515.	-3619.	5139.	2756.	7473
4	6000	-.69895	18463.	-2034.	18302.	-5198.	8573.	4530.	11575
4	8000	-.69473	24111.	-2302.	23840.	-6444.	11428.	5967.	14894
5	300	.65192	527.	-370.	577.	-452.	198.	-73.	-496
5	600	.65707	855.	-699.	953.	-828.	288.	-163.	-862
5	1000	.66411	1471.	-1158.	1632.	-1382.	487.	-237.	-1463
5	1500	.68570	2121.	-1598.	2340.	-1924.	630.	-214.	-2090
5	2000	.70778	2990.	-1945.	3246.	-2413.	854.	-20.	-2795
5	4000	.75426	6718.	-3009.	7055.	-4097.	1826.	1132.	-5565
5	6000	-.78008	11191.	-3668.	11518.	-5518.	3090.	2909.	8518
5	8000	-.75169	15029.	-4111.	15327.	-6619.	5093.	3614.	10948

Table 11 Experimental Stresses for Run 10

RUN NUMBER 10 350 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.75656	430.	-482.	502.	-544.	9.	-51.	-522
1	600	.69033	678.	-992.	832.	-1082.	56.	-306.	-940
1	1000	.70730	1033.	-1503.	1267.	-1642.	38.	-413.	-1437
1	1500	.69033	1470.	-2149.	1804.	-2346.	121.	-663.	-2038
1	2000	.70730	1970.	-2597.	2368.	-2868.	157.	-657.	-2586
1	4000	.72159	3848.	-4423.	4512.	-4971.	374.	-832.	-4703
1	6000	.74066	5821.	-5664.	6647.	-6522.	650.	-525.	-6558
1	8000	.76264	8041.	-6422.	8937.	-7645.	1022.	268.	-8283
2	300	-.58237	752.	-413.	803.	-532.	399.	-128.	614
2	600	-.55524	1381.	-780.	1479.	-999.	790.	-311.	1110
2	1000	-.54388	2168.	-1202.	2318.	-1547.	1283.	-512.	1711
2	1500	-.51904	3270.	-1729.	3481.	-2251.	2070.	-841.	2469
2	2000	-.50980	4335.	-2272.	4610.	-2965.	2806.	-1160.	3227
2	4000	-.48170	8926.	-4146.	9400.	-5587.	6183.	-2370.	6153
2	6000	-.47347	13084.	-5588.	13694.	-7715.	9242.	-3263.	8688
2	8000	-.46706	17050.	-6785.	17758.	-9571.	12217.	-4030.	10987
3	300	-.56201	750.	-437.	805.	-555.	419.	-169.	614
3	600	-.56523	1383.	-808.	1485.	-1027.	764.	-306.	1136
3	1000	-.57550	2099.	-1419.	2288.	-1746.	1093.	-551.	1842
3	1500	-.57856	3170.	-2230.	3471.	-2721.	1619.	-869.	2835
3	2000	-.58293	4205.	-3108.	4630.	-3755.	2089.	-1214.	3854
3	4000	-.59014	9142.	-7000.	10108.	-8400.	4376.	-2668.	8557
3	6000	-.59266	13953.	-9878.	15287.	-12037.	6761.	-3511.	12660
3	8000	-.59856	18857.	-11961.	20418.	-14918.	9199.	-3699.	16448

Table 11 (Continued) Experimental Stresses for Run 10

RUN NUMBER 10 — 350 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.74425	821.	-299.	850.	-434.	261.	155.	640
4	600	-.72669	1641.	-492.	1681.	-765.	601.	315.	1215
4	1000	.77730	2708.	269.	2585.	-210.	1210.	1164.	-1397
4	1500	-.71796	4062.	-928.	4111.	-1611.	1634.	865.	2835
4	2000	-.71643	5495.	-1107.	5535.	-2035.	2270.	1229.	3749
4	4000	-.70451	12313.	-1656.	12258.	-3758.	5539.	2960.	7904
4	6000	-.69823	18739.	-1971.	18560.	-5185.	8746.	4628.	11693
4	8000	-.69381	25031.	-2202.	24716.	-6508.	11947.	6260.	15351
5	300	.72095	471.	-654.	572.	-718.	10.	-155.	-640
5	600	.70415	922.	-948.	1061.	-1082.	163.	-183.	-1058
5	1000	.70266	1463.	-1332.	1654.	-1550.	316.	-211.	-1580
5	1500	.71170	2211.	-1820.	2467.	-2155.	495.	-183.	-2286
5	2000	.72340	3011.	-2201.	3311.	-2665.	692.	-46.	-2965
5	4000	.76349	7204.	-3312.	7580.	-4476.	1816.	1288.	-6022
5	6000	-.77378	11448.	-3847.	11800.	-5737.	3234.	2827.	8766
5	8000	-.74415	15715.	-4248.	16017.	-6871.	5515.	3630.	11405

Table 12 Experimental Stresses for Run 11

RUN NUMBER 11 425 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.64830	357.	-566.	445.	-612.	59.	-226.	-509
1	600	.66637	600.	-1018.	760.	-1094.	52.	-385.	-901
1	1000	.67778	1123.	-1279.	1314.	-1439.	231.	-356.	-1345
1	1500	.66626	1595.	-1804.	1866.	-2032.	376.	-543.	-1894
1	2000	.58319	1733.	-3248.	2252.	-3460.	519.	-1728.	-2626
1	4000	.72853	4127.	-4336.	4769.	-4935.	467.	-633.	-4821
1	6000	.74876	6387.	-5655.	7195.	-6612.	797.	-213.	-6885
1	8000	.77486	9113.	-6501.	9993.	-7909.	1230.	853.	-8949
2	300	-.58372	752.	-387.	799.	-507.	402.	-110.	600
2	600	-.55643	1302.	-780.	1402.	-986.	736.	-319.	1071
2	1000	-.55150	2208.	-1059.	2331.	-1415.	1303.	-386.	1672
2	1500	-.51896	3270.	-1650.	3467.	-2175.	2079.	-787.	2430
2	2000	-.50996	4492.	-2194.	4749.	-2916.	2923.	-1089.	3266
2	4000	-.48309	9397.	-4120.	9853.	-5645.	6509.	-2301.	6375
2	6000	-.47119	13956.	-5650.	14553.	-7928.	9920.	-3295.	9093
2	8000	-.46506	18676.	-7079.	19389.	-10139.	13450.	-4200.	11836
3	300	-.57558	731.	-366.	775.	-483.	402.	-110.	574
3	600	-.57371	1286.	-763.	1383.	-966.	691.	-274.	1071
3	1000	-.58019	2237.	-1192.	2382.	-1549.	1201.	-367.	1802
3	1500	-.57819	3188.	-2039.	3455.	-2539.	1665.	-748.	2743
3	2000	-.58268	4422.	-3116.	4843.	-3801.	2225.	-1183.	3971
3	4000	-.58868	9672.	-7008.	10625.	-8500.	4728.	-2603.	8831
3	6000	-.59224	15079.	-10064.	16414.	-12414.	7431.	-3431.	13352
3	8000	-.59838	21134.	-12358.	22700.	-15700.	10515.	-3515.	17872

Table 12 (Continued) Experimental Stresses for Run 11

RUN NUMBER 11 — 425 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.72095	811.	-314.	843.	-447.	280.	114.	640
4	600	-.71616	1510.	-491.	1553.	-741.	564.	247.	1136
4	1000	-.71125	2653.	-641.	2691.	-1086.	1081.	522.	1868
4	1500	-.71140	4008.	-899.	4053.	-1574.	1654.	824.	2782
4	2000	-.70818	5716.	-1041.	5738.	-2009.	2460.	1268.	3828
4	4000	-.70410	12796.	-1591.	12717.	-3779.	5803.	3133.	8139
4	6000	-.69505	19970.	-1922.	19748.	-5352.	9453.	4942.	12346
4	8000	-.69062	27468.	-2211.	27087.	-6942.	13278.	6867.	16710
5	300	.62706	482.	-404.	539.	-477.	189.	-127.	-483
5	600	.67109	901.	-666.	992.	-804.	297.	-109.	-875
5	1000	.66840	1472.	-1080.	1620.	-1307.	495.	-183.	-1424
5	1500	.68458	2225.	-1519.	2428.	-1865.	711.	-148.	-2103
5	2000	.70776	3235.	-1955.	3485.	-2465.	970.	50.	-2939
5	4000	.76151	7684.	-3061.	8004.	-4316.	2137.	1549.	-6153
5	6000	-.77177	12316.	-3619.	12604.	-5667.	3717.	3219.	9132
5	8000	-.73484	17454.	-4055.	17674.	-6987.	6588.	4099.	12268

Table 13 Experimental Stresses for Run 12

RUN NUMBER 12 — 500 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.73743	372.	-451.	441.	-503.	14.	-76.	-470
1	600	.66529	630.	-917.	773.	-1002.	96.	-325.	-862
1	1000	.66335	1028.	-1367.	1237.	-1508.	196.	-467.	-1332
1	1500	.67879	1404.	-1953.	1706.	-2143.	188.	-626.	-1881
1	2000	.68734	1860.	-2461.	2238.	-2717.	243.	-722.	-2430
1	4000	.70991	3706.	-3993.	4299.	-4528.	549.	-778.	-4363
1	6000	.73498	5451.	-5268.	6218.	-6072.	691.	-545.	-6114
1	8000	.76151	7661.	-6119.	8514.	-7285.	991.	237.	-7891
2	300	-.57685	614.	-457.	676.	-551.	311.	-186.	561
2	600	-.56365	1205.	-787.	1309.	-976.	656.	-323.	1032
2	1000	-.54186	2030.	-1090.	2163.	-1413.	1212.	-462.	1580
2	1500	-.52610	2974.	-1564.	3164.	-2039.	1852.	-727.	2260
2	2000	-.51416	3960.	-2079.	4212.	-2712.	2537.	-1037.	2965
2	4000	-.49000	8187.	-3694.	8603.	-5020.	5585.	-2002.	5657
2	6000	-.47744	12029.	-5029.	12571.	-6988.	8441.	-2858.	7982
2	8000	-.46908	16036.	-6372.	16700.	-8992.	11450.	-3741.	10360
3	300	-.59154	635.	-374.	682.	-474.	322.	-114.	535
3	600	-.58184	1189.	-771.	1290.	-957.	611.	-278.	1032
3	1000	-.59354	1947.	-1320.	2123.	-1623.	951.	-451.	1737
3	1500	-.59956	2748.	-2069.	3033.	-2491.	1274.	-732.	2573
3	2000	-.60630	3713.	-2929.	4120.	-3495.	1647.	-1022.	3566
3	4000	-.60857	7876.	-6675.	8821.	-7863.	3368.	-2409.	7825
3	6000	-.60914	12070.	-9614.	13410.	-11452.	5271.	-3312.	11667
3	8000	-.61044	16855.	-11892.	18459.	-14501.	7628.	-3670.	15482

Table 13 (Continued) Experimental Stresses for Run 12

RUN NUMBER 12 | 500 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.71709	705.	-261.	730.	-376.	252.	101.	548
4	600	-.72236	1451.	-432.	1486.	-673.	542.	270.	1071
4	1000	-.71788	2438.	-688.	2491.	-1095.	939.	456.	1776
4	1500	-.71873	3673.	-879.	3724.	-1495.	1461.	767.	2586
4	2000	-.71586	5061.	-1013.	5097.	-1868.	2097.	1131.	3449
4	4000	-.70990	11178.	-1592.	11144.	-3498.	4924.	2721.	7238
4	6000	-.70443	17133.	-1801.	16969.	-4740.	7864.	4364.	10713
4	8000	-.69671	23575.	-2078.	23279.	-6133.	11167.	5978.	14476
5	300	.60935	439.	-361.	490.	-428.	189.	-127.	-431
5	600	.64699	837.	-654.	928.	-782.	306.	-160.	-823
5	1000	.67453	1370.	-1082.	1520.	-1291.	423.	-194.	-1371
5	1500	.68910	2027.	-1478.	2228.	-1791.	603.	-165.	-1972
5	2000	.70985	2773.	-1859.	3020.	-2291.	764.	-35.	-2626
5	4000	.75211	6515.	-2780.	6818.	-3839.	1844.	1135.	-5317
5	6000	.78492	10433.	-3354.	10727.	-5081.	2830.	2815.	-7904
5	8000	-.75596	14700.	-3860.	14963.	-6317.	4948.	3696.	10621

Table 14 Experimental Stresses for Run 13

RUN NUMBER 13 — 575 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.67191	311.	-390.	371.	-433.	59.	-121.	-391
1	600	.68192	572.	-964.	724.	-1037.	24.	-337.	-862
1	1000	.67496	987.	-1535.	1227.	-1664.	98.	-535.	-1411
1	1500	.67967	1517.	-2118.	1844.	-2324.	197.	-677.	-2038
1	2000	.69493	2039.	-2640.	2443.	-2922.	243.	-722.	-2639
1	4000	.72516	4152.	-4387.	4801.	-4989.	494.	-682.	-4860
1	6000	.74842	6434.	-5677.	7245.	-6641.	815.	-210.	-6924
1	8000	.77361	9007.	-6630.	9913.	-8017.	1159.	736.	-8962
2	300	-.59527	635.	-321.	673.	-423.	328.	-78.	509
2	600	-.54797	1144.	-726.	1239.	-905.	656.	-323.	953
2	1000	-.53723	2089.	-1253.	2249.	-1583.	1246.	-579.	1685
2	1500	-.51894	3152.	-1742.	3368.	-2243.	1988.	-863.	2417
2	2000	-.50655	4414.	-2273.	4688.	-2979.	2883.	-1174.	3253
2	4000	-.48124	9320.	-4148.	9784.	-5659.	6475.	-2350.	6336
2	6000	-.47032	13959.	-5757.	14574.	-8032.	9931.	-3389.	9132
2	8000	-.46430	18600.	-7212.	19339.	-10256.	13404.	-4321.	11849
3	300	-.58602	653.	-261.	680.	-368.	359.	-47.	483
3	600	-.57714	1207.	-711.	1297.	-902.	642.	-247.	1006
3	1000	-.57283	2117.	-1359.	2295.	-1691.	1124.	-520.	1816
3	1500	-.57791	3110.	-2144.	3397.	-2626.	1599.	-829.	2756
3	2000	-.58247	4422.	-3142.	4847.	-3826.	2222.	-1201.	3984
3	4000	-.58837	9672.	-7086.	10638.	-8576.	4719.	-2657.	8871
3	6000	-.59188	15157.	-10116.	16499.	-12479.	7479.	-3458.	13417
3	8000	-.59759	21091.	-12446.	22674.	-15778.	10500.	-3604.	17886

Table 14 (Continued) Experimental Stresses for Run 13

RUN NUMBER 13 — 575 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.72016	766.	-244.	788.	-371.	283.	132.	574
4	600	-.71544	1387.	-499.	1436.	-727.	505.	203.	1071
4	1000	-.71765	2622.	-689.	2669.	-1127.	1027.	514.	1881
4	1500	-.71896	4024.	-942.	4076.	-1617.	1606.	852.	2822
4	2000	-.71230	5730.	-1133.	5768.	-2102.	2406.	1260.	3893
4	4000	-.70429	12919.	-1583.	12834.	-3793.	5863.	3178.	8204
4	6000	-.69753	20153.	-1974.	19935.	-5435.	9467.	5032.	12490
4	8000	-.69105	27514.	-2230.	27135.	-6968.	13281.	6885.	16749
5	300	.70730	537.	-223.	561.	-311.	192.	57.	-431
5	600	.64283	850.	-693.	947.	-822.	311.	-186.	-849
5	1000	.66551	1406.	-1197.	1576.	-1409.	437.	-271.	-1450
5	1500	.68919	2179.	-1605.	2398.	-1940.	644.	-185.	-2129
5	2000	.71092	3190.	-2041.	3457.	-2540.	903.	13.	-2965
5	4000	.75772	7624.	-3080.	7949.	-4324.	2151.	1473.	-6127
5	6000	-.77270	12450.	-3621.	12734.	-5692.	3754.	3286.	9210
5	8000	-.73748	17481.	-4108.	17710.	-7043.	6517.	4149.	12320

Table 15 Experimental Stresses for Run 14

RUN NUMBER 14 650 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.67977	342.	-473.	415.	-519.	45.	-150.	-457
1	600	.66960	661.	-1001.	817.	-1088.	83.	-354.	-927
1	1000	.66756	1076.	-1572.	1320.	-1716.	156.	-552.	-1476
1	1500	.68794	1552.	-2048.	1866.	-2262.	201.	-597.	-2025
1	2000	.69214	2076.	-2677.	2486.	-2965.	265.	-744.	-2678
1	4000	.71239	4126.	-4465.	4790.	-5061.	581.	-852.	-4873
1	6000	.74456	6400.	-5695.	7215.	-6653.	846.	-284.	-6911
1	8000	.77065	8971.	-6646.	9880.	-8026.	1191.	663.	-8949
2	300	-.59154	635.	-374.	682.	-474.	322.	-114.	535
2	600	-.55685	1263.	-793.	1366.	-991.	707.	-332.	1058
2	1000	-.53745	2089.	-1201.	2240.	-1532.	1251.	-543.	1659
2	1500	-.51894	3231.	-1663.	3431.	-2181.	2050.	-800.	2417
2	2000	-.50991	4453.	-2207.	4714.	-2922.	2894.	-1103.	3253
2	4000	-.48301	9357.	-4133.	9817.	-5651.	6480.	-2314.	6362
2	6000	-.47112	13917.	-5663.	14517.	-7933.	9891.	-3308.	9080
2	8000	-.46488	18558.	-7118.	19282.	-10157.	13365.	-4240.	11797
3	300	-.56789	632.	-397.	684.	-496.	342.	-155.	535
3	600	-.59067	1192.	-852.	1307.	-1036.	580.	-309.	1084
3	1000	-.43104	1290.	-1681.	1547.	-1859.	952.	-1265.	1293
3	1500	-.58021	3131.	-2112.	3412.	-2600.	1605.	-793.	2756
3	2000	-.58492	4365.	-3085.	4781.	-3760.	2177.	-1156.	3932
3	4000	-.58679	9609.	-7023.	10566.	-8503.	4719.	-2657.	8792
3	6000	-.59114	15016.	-10027.	16346.	-12367.	7428.	-3448.	13287
3	8000	-.59661	21027.	-12486.	22619.	-15806.	10489.	-3676.	17859

Table 15 (Continued) Experimental Stresses for Run 14

RUN NUMBER 14 650 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.74250	798.	-276.	824.	-407.	261.	155.	614
4	600	-.72268	1495.	-502.	1541.	-749.	539.	252.	1136
4	1000	-.71520	2559.	-731.	2616.	-1157.	993.	465.	1868
4	1500	-.71937	4041.	-855.	4078.	-1536.	1640.	901.	2782
4	2000	-.71491	5716.	-1119.	5752.	-2085.	2383.	1282.	3880
4	4000	-.70436	12858.	-1574.	12774.	-3774.	5835.	3164.	8165
4	6000	-.69801	19972.	-1897.	19745.	-5329.	9388.	5028.	12346
4	8000	-.69105	27575.	-2239.	27196.	-6987.	13309.	6898.	16788
5	300	.64869	479.	-348.	526.	-422.	180.	-76.	-457
5	600	.66295	852.	-721.	954.	-850.	270.	-166.	-875
5	1000	.67043	1416.	-1181.	1583.	-1395.	433.	-245.	-1450
5	1500	.68803	2196.	-1543.	2404.	-1883.	675.	-154.	-2103
5	2000	.70708	3134.	-2011.	3397.	-2501.	908.	-12.	-2913
5	4000	.76120	7616.	-2993.	7926.	-4238.	2137.	1549.	-6075
5	6000	-.77094	12369.	-3567.	12646.	-5625.	3774.	3246.	9132
5	8000	-.73637	17572.	-4068.	17791.	-7020.	6599.	4170.	12346

Table 16 Experimental Stresses for Run 15

RUN NUMBER 15 — 725 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.71372	316.	-604.	413.	-642.	-39.	-190.	-522
1	600	.70365	560.	-1056.	728.	-1124.	-47.	-348.	-914
1	1000	.67937	1127.	-1623.	1379.	-1774.	133.	-529.	-1541
1	1500	.68702	1651.	-2252.	1998.	-2477.	197.	-677.	-2194
1	2000	.69298	2107.	-2760.	2530.	-3051.	252.	-773.	-2743
1	4000	.71446	4073.	-4674.	4775.	-5254.	469.	-948.	-4964
1	6000	.74379	6448.	-5900.	7298.	-6860.	807.	-369.	-7055
1	8000	.77129	9044.	-6824.	9982.	-8211.	1141.	628.	-9093
2	300	-.58372	674.	-465.	736.	-570.	339.	-173.	600
2	600	-.54420	1341.	-871.	1455.	-1080.	775.	-400.	1123
2	1000	-.53652	2286.	-1241.	2438.	-1605.	1382.	-548.	1776
2	1500	-.51493	3467.	-1796.	3684.	-2351.	2220.	-887.	2586
2	2000	-.50407	4651.	-2353.	4932.	-3099.	3058.	-1225.	3396
2	4000	-.48073	9558.	-4282.	10038.	-5830.	6645.	-2436.	6506
2	6000	-.47109	14155.	-5849.	14780.	-8155.	10056.	-3431.	9276
2	8000	-.46415	18838.	-7293.	19584.	-10376.	13580.	-4372.	11993
3	300	-.59974	656.	-395.	707.	-498.	322.	-114.	561
3	600	-.58177	1366.	-792.	1467.	-1008.	719.	-261.	1136
3	1000	-.57731	2276.	-1336.	2446.	-1696.	1212.	-462.	1894
3	1500	-.58241	3390.	-2240.	3686.	-2769.	1733.	-816.	2965
3	2000	-.58756	4545.	-3135.	4965.	-3840.	2259.	-1134.	4063
3	4000	-.58717	9868.	-7203.	10849.	-8724.	4841.	-2716.	9027
3	6000	-.59146	15275.	-10155.	16620.	-12537.	7555.	-3472.	13496
3	8000	-.59763	21407.	-12422.	22977.	-15811.	10696.	-3529.	18042

Table 16 (Continued) Experimental Stresses for Run 15

RUN NUMBER 15 725 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.71917	872.	-323.	904.	-466.	309.	128.	679
4	600	-.71824	1616.	-545.	1666.	-812.	593.	261.	1228
4	1000	-.71278	2759.	-695.	2803.	-1157.	1109.	536.	1959
4	1500	-.71310	4359.	-937.	4401.	-1672.	1802.	927.	3004
4	2000	-.71097	5991.	-1106.	6016.	-2121.	2551.	1344.	4024
4	4000	-.70378	13179.	-1556.	13083.	-3812.	6008.	3262.	8335
4	6000	-.69535	20398.	-1932.	20166.	-5437.	9657.	5071.	12594
4	8000	-.69033	27850.	-2227.	27461.	-7024.	13477.	6960.	16932
5	300	.61311	474.	-421.	534.	-492.	194.	-152.	-483
5	600	.65037	889.	-837.	1010.	-968.	284.	-243.	-953
5	1000	.66212	1531.	-1218.	1701.	-1451.	509.	-259.	-1528
5	1500	.69245	2420.	-1637.	2638.	-2013.	742.	-117.	-2286
5	2000	.70796	3314.	-2060.	3581.	-2581.	975.	24.	-3044
5	4000	.76070	7841.	-3088.	8161.	-4369.	2205.	1586.	-6258
5	6000	-.77050	12666.	-3681.	12955.	-5788.	3862.	3304.	9367
5	8000	-.73698	17825.	-4087.	18041.	-7082.	6693.	4264.	12503

Table 17 Experimental Stresses for Run 16

RUN NUMBER 16 800 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.67319	411.	-594.	503.	-649.	55.	-201.	-561
1	600	.65431	720.	-955.	866.	-1054.	155.	-342.	-927
1	1000	.67726	1096.	-1540.	1334.	-1688.	147.	-501.	-1476
1	1500	.66461	1542.	-2142.	1872.	-2352.	265.	-744.	-2051
1	2000	.68304	2062.	-2662.	2469.	-2948.	311.	-790.	-2652
1	4000	.70575	4019.	-4359.	4667.	-4938.	626.	-897.	-4742
1	6000	.75054	6382.	-5520.	7167.	-6479.	818.	-131.	-6806
1	8000	.76089	8634.	-6675.	9558.	-7995.	1211.	351.	-8766
2	300	-.60327	816.	-476.	876.	-605.	399.	-128.	692
2	600	-.57069	1442.	-737.	1531.	-968.	801.	-239.	1136
2	1000	-.55170	2386.	-1263.	2540.	-1644.	1390.	-494.	1868
2	1500	-.53017	3447.	-1750.	3656.	-2302.	2132.	-778.	2599
2	2000	-.51868	4668.	-2291.	4938.	-3042.	2977.	-1081.	3436
2	4000	-.49082	9487.	-4080.	9934.	-5622.	6478.	-2165.	6467
2	6000	-.47668	14044.	-5660.	14640.	-7952.	9883.	-3196.	9210
2	8000	-.46965	18485.	-7123.	19212.	-10150.	13198.	-4135.	11849
3	300	-.58107	930.	-460.	984.	-609.	504.	-129.	731
3	600	-.57721	1562.	-779.	1655.	-1030.	855.	-230.	1228
3	1000	-.57877	2436.	-1495.	2629.	-1879.	1280.	-530.	2064
3	1500	-.58608	3591.	-2442.	3917.	-3000.	1801.	-884.	3187
3	2000	-.58405	4820.	-3305.	5262.	-4053.	2429.	-1221.	4285
3	4000	-.58688	9985.	-7164.	10956.	-8706.	4926.	-2676.	9067
3	6000	-.59111	15392.	-10168.	16737.	-12570.	7635.	-3468.	13561
3	8000	-.59631	21163.	-12334.	22724.	-15682.	10611.	-3569.	17846

Table 17 (Continued) Experimental Stresses for Run 16

RUN NUMBER 16 800 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.73178	1041.	-310.	1066.	-483.	374.	208.	770
4	600	-.72322	1740.	-487.	1777.	-777.	658.	341.	1267
4	1000	-.73227	2870.	-728.	2917.	-1208.	1072.	635.	2051
4	1500	-.72498	4424.	-924.	4462.	-1670.	1765.	1026.	3044
4	2000	-.71709	6130.	-1115.	6154.	-2154.	2565.	1434.	4115
4	4000	-.70763	13119.	-1574.	13028.	-3819.	5909.	3299.	8322
4	6000	-.69711	20291.	-1955.	20066.	-5441.	9552.	5072.	12555
4	8000	-.69308	27436.	-2309.	27073.	-7031.	13151.	6890.	16762
5	300	.65707	583.	-453.	646.	-542.	202.	-98.	-574
5	600	.65980	990.	-703.	1085.	-856.	355.	-126.	-940
5	1000	.67470	1548.	-1208.	1715.	-1444.	482.	-211.	-1541
5	1500	.69033	2423.	-1614.	2637.	-1992.	760.	-114.	-2273
5	2000	.71128	3339.	-2006.	3595.	-2533.	983.	78.	-3031
5	4000	.75582	7732.	-2952.	8031.	-4218.	2268.	1544.	-6114
5	6000	-.77555	12450.	-3596.	12730.	-5668.	3712.	3350.	9197
5	8000	-.73936	17355.	-4112.	17588.	-7025.	6412.	4149.	12255

Table 18 Experimental Stresses for Run 17

RUN NUMBER 17 900 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.64488	275.	-484.	351.	-518.	37.	-204.	-418
1	600	.64488	618.	-1089.	791.	-1166.	84.	-459.	-940
1	1000	.65444	1060.	-1582.	1306.	-1723.	183.	-600.	-1463
1	1500	.68321	1528.	-2102.	1852.	-2310.	193.	-651.	-2038
1	2000	.67572	2044.	-2671.	2453.	-2953.	338.	-838.	-2639
1	4000	.70147	4018.	-4488.	4688.	-5063.	627.	-1002.	-4807
1	6000	.73706	6286.	-5711.	7107.	-6649.	892.	-434.	-6846
1	8000	.76491	8806.	-6612.	9714.	-7964.	1237.	512.	-8831
2	300	-.59154	674.	-834.	714.	-443.	354.	-83.	535
2	600	-.56426	1422.	-821.	1526.	-1046.	790.	-311.	1162
2	1000	-.54886	2366.	-1243.	2517.	-1621.	1390.	-494.	1842
2	1500	-.52801	3427.	-1730.	3634.	-2279.	2132.	-778.	2573
2	2000	-.51701	4649.	-2272.	4915.	-3020.	2977.	-1081.	3409
2	4000	-.48695	9472.	-4222.	9944.	-5757.	6506.	-2318.	6493
2	6000	-.47676	14183.	-5798.	14799.	-8111.	9974.	-3286.	9341
2	8000	-.46979	18702.	-7183.	19433.	-10246.	13351.	-4163.	11980
3	300	-.56789	711.	-319.	746.	-434.	405.	-92.	535
3	600	-.57052	1542.	-889.	1654.	-1133.	841.	-320.	1267
3	1000	-.58070	2456.	-1542.	2657.	-1928.	1277.	-548.	2103
3	1500	-.58184	3528.	-2353.	3840.	-2903.	1803.	-866.	3096
3	2000	-.58455	4840.	-3404.	5299.	-4153.	2420.	-1275.	4350
3	4000	-.58589	9964.	-7274.	10955.	-8809.	4912.	-2766.	9106
3	6000	-.58975	15684.	-10225.	17031.	-12676.	7841.	-3487.	13731
3	8000	-.59593	21419.	-12407.	22986.	-15798.	10767.	-3579.	18016

Table 18 (Continued) Experimental Stresses for Run 17

RUN NUMBER 17 — 900 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.74425	715.	-245.	738.	-363.	232.	142.	548
4	600	-.71372	1653.	-556.	1704.	-829.	618.	256.	1254
4	1000	-.72359	2859.	-769.	2913.	-1246.	1089.	576.	2064
4	1500	-.71993	4292.	-948.	4337.	-1671.	1725.	941.	2978
4	2000	-.71778	6092.	-1129.	6119.	-2161.	2537.	1420.	4102
4	4000	-.70666	13156.	-1611.	13070.	-3862.	5931.	3276.	8361
4	6000	-.69797	20621.	-1919.	20380.	-5464.	9706.	5210.	12725
4	8000	-.69263	27751.	-2207.	27362.	-6987.	13355.	7019.	16880
5	300	.63208	435.	-305.	476.	-372.	180.	-76.	-405
5	600	.66518	947.	-765.	1054.	-909.	306.	-160.	-953
5	1000	.66869	1563.	-1224.	1733.	-1462.	505.	-234.	-1554
5	1500	.68811	2292.	-1586.	2505.	-1942.	711.	-148.	-2181
5	2000	.70796	3353.	-2021.	3612.	-2549.	1006.	56.	-3044
5	4000	.75807	7810.	-3030.	8121.	-4308.	2245.	1566.	-6205
5	6000	-.77443	12687.	-3519.	12947.	-5635.	3859.	3452.	9289
5	8000	-.74140	17660.	-4051.	17873.	-7019.	6520.	4333.	12398

Table 19 Experimental Stresses for Run 18

RUN NUMBER 18 — 1000 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
1	300	.67191	363.	-572.	453.	-619.	37.	-204.	-522
1	600	.64869	645.	-1011.	803.	-1095.	110.	-402.	-914
1	1000	.64982	1016.	-1538.	1256.	-1672.	183.	-600.	-1411
1	1500	.66911	1487.	-2166.	1823.	-2365.	211.	-753.	-2038
1	2000	.67913	2020.	-2595.	2417.	-2875.	329.	-787.	-2586
1	4000	.70758	4061.	-4427.	4720.	-5012.	608.	-900.	-4807
1	6000	.73798	6236.	-5713.	7059.	-6642.	857.	-440.	-6819
1	8000	.76012	8545.	-6560.	9451.	-7868.	1229.	354.	-8649
2	300	-.58841	773.	-460.	832.	-582.	396.	-146.	653
2	600	-.56905	1443.	-816.	1545.	-1045.	793.	-293.	1175
2	1000	-.54611	2346.	-1196.	2489.	-1572.	1393.	-477.	1802
2	1500	-.52576	3408.	-1841.	3634.	-2384.	2118.	-868.	2613
2	2000	-.51535	4629.	-2279.	4898.	-3023.	2974.	-1099.	3396
2	4000	-.48795	9569.	-4189.	10033.	-5741.	6566.	-2274.	6532
2	6000	-.47724	14201.	-5739.	14806.	-8056.	9982.	-3232.	9328
2	8000	-.47021	18365.	-7081.	19088.	-10088.	13099.	-4099.	11784
3	300	-.57642	870.	-426.	920.	-566.	478.	-124.	679
3	600	-.58107	1544.	-839.	1648.	-1085.	824.	-261.	1254
3	1000	-.58184	2417.	-1503.	2612.	-1883.	1254.	-525.	2064
3	1500	-.58514	3531.	-2408.	3852.	-2957.	1775.	-879.	3135
3	2000	-.58594	4801.	-3260.	5236.	-4007.	2409.	-1180.	4259
3	4000	-.58701	10045.	-7251.	11030.	-8801.	4946.	-2717.	9145
3	6000	-.59023	15645.	-10082.	16968.	-12530.	7830.	-3393.	13639
3	8000	-.59527	21018.	-12163.	22553.	-15491.	10591.	-3529.	17663

Table 19 (Continued) Experimental Stresses for Run 18

RUN NUMBER 18 — 1000 CYCLES

GAGE NO.	LOAD (LB)	PHI P (RAD.)	SIGMA MAX (PSI)	SIGMA MIN (PSI)	SIGMA 1 (PSI)	SIGMA 2 (PSI)	SIGMA X (PSI)	SIGMA Y (PSI)	TAU XY (PSI)
4	300	-.71233	887.	-287.	913.	-433.	337.	141.	666
4	600	-.72192	1678.	-503.	1719.	-782.	627.	310.	1241
4	1000	-.71692	2866.	-698.	2908.	-1179.	1143.	585.	2025
4	1500	-.72145	4315.	-946.	4360.	-1672.	1728.	959.	2991
4	2000	-.71349	5976.	-1092.	6000.	-2104.	2528.	1367.	4010
4	4000	-.70707	13301.	-1626.	13214.	-3901.	5991.	3321.	8453
4	6000	-.69955	20492.	-1921.	20255.	-5442.	9601.	5211.	12660
4	8000	-.69355	27255.	-2206.	26879.	-6900.	13074.	6904.	16605
5	300	.61615	547.	-443.	609.	-526.	230.	-146.	-535
5	600	.64305	918.	-814.	1035.	-952.	320.	-237.	-953
5	1000	.66006	1509.	-1195.	1675.	-1425.	509.	-259.	-1502
5	1500	.69140	2320.	-1693.	2550.	-2050.	679.	-179.	-2260
5	2000	.69927	3275.	-2021.	3536.	-2536.	1020.	-20.	-2991
5	4000	.75710	7843.	-3090.	8164.	-4372.	2250.	1541.	-6258
5	6000	-.75746	11628.	-3687.	11947.	-5613.	3656.	2676.	8766
5	8000	-.74442	17298.	-4082.	17527.	-6986.	6274.	4267.	12215

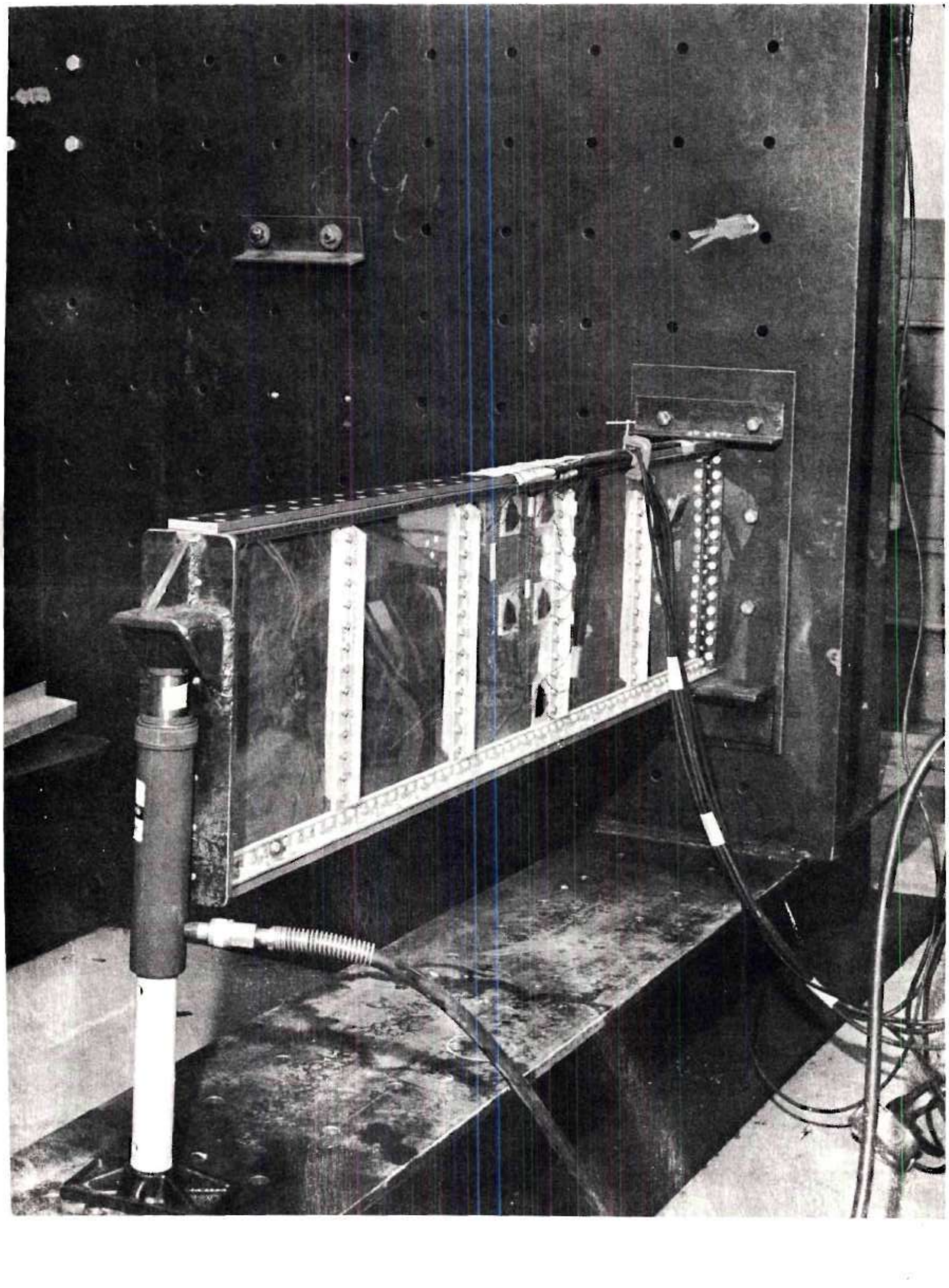
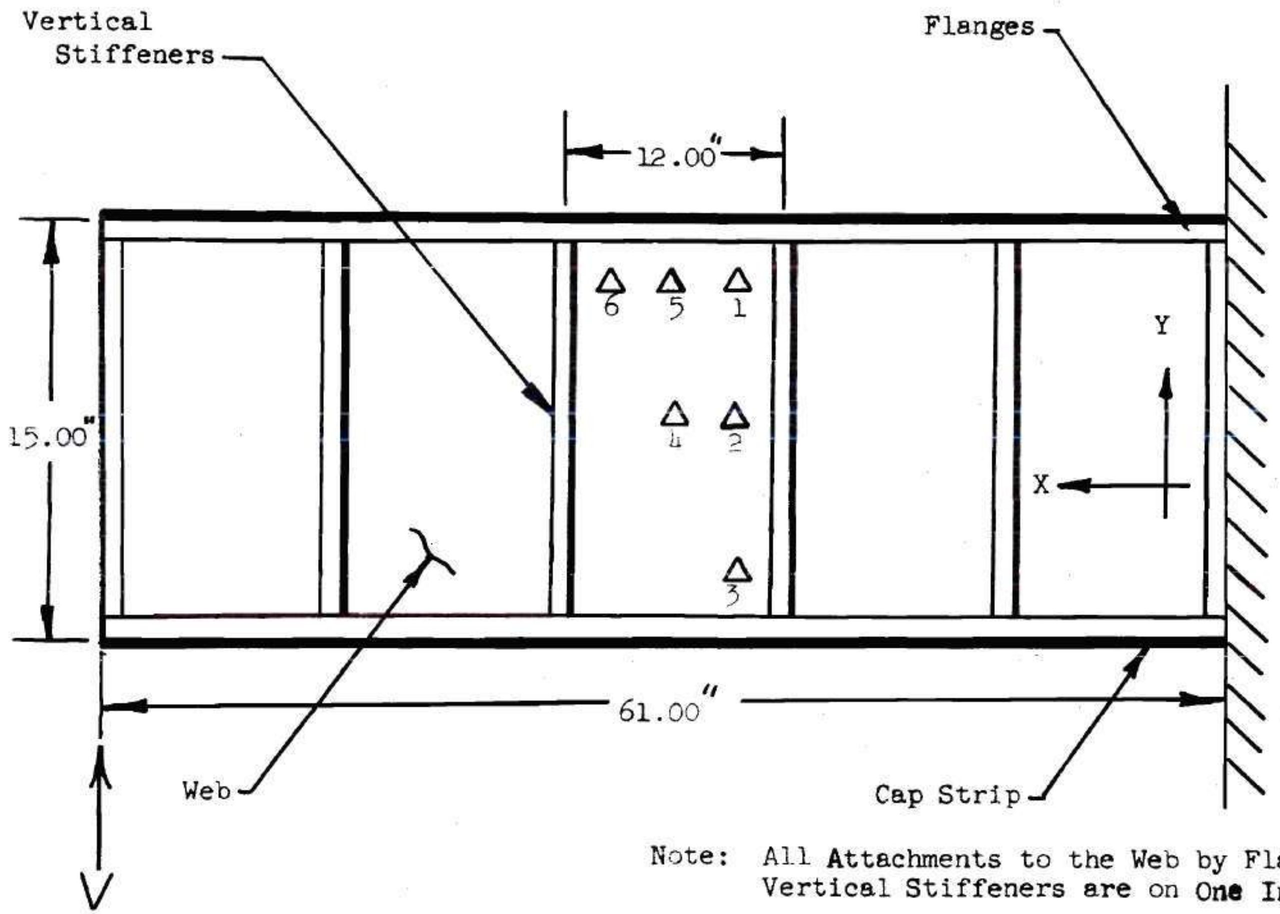


Figure 1. Test Beam



Note: All Attachments to the Web by Flanges and Vertical Stiffeners are on One Inch Spacing

Figure 2. Diagram of Test Beam

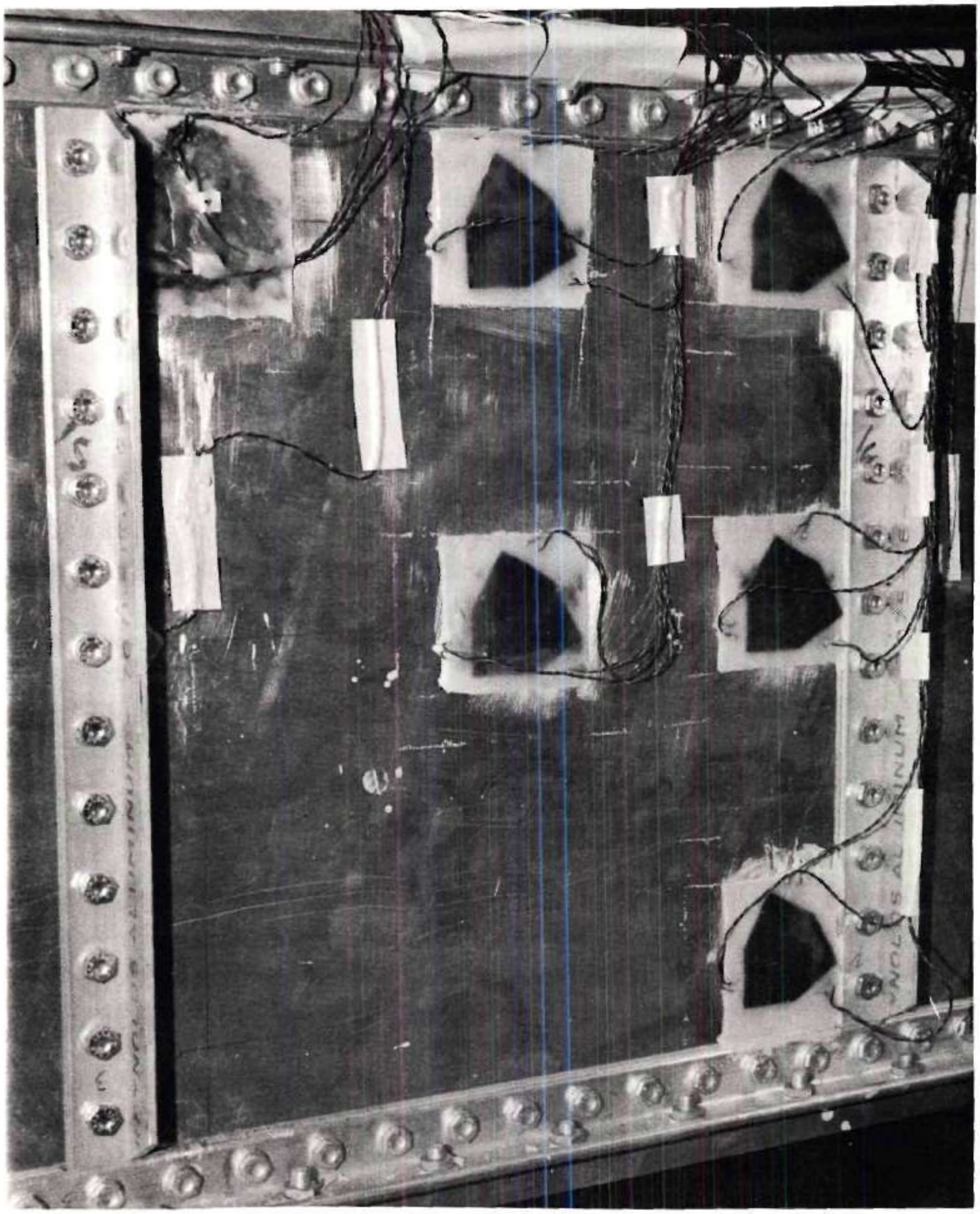


Figure 3. Location of Strain Gages

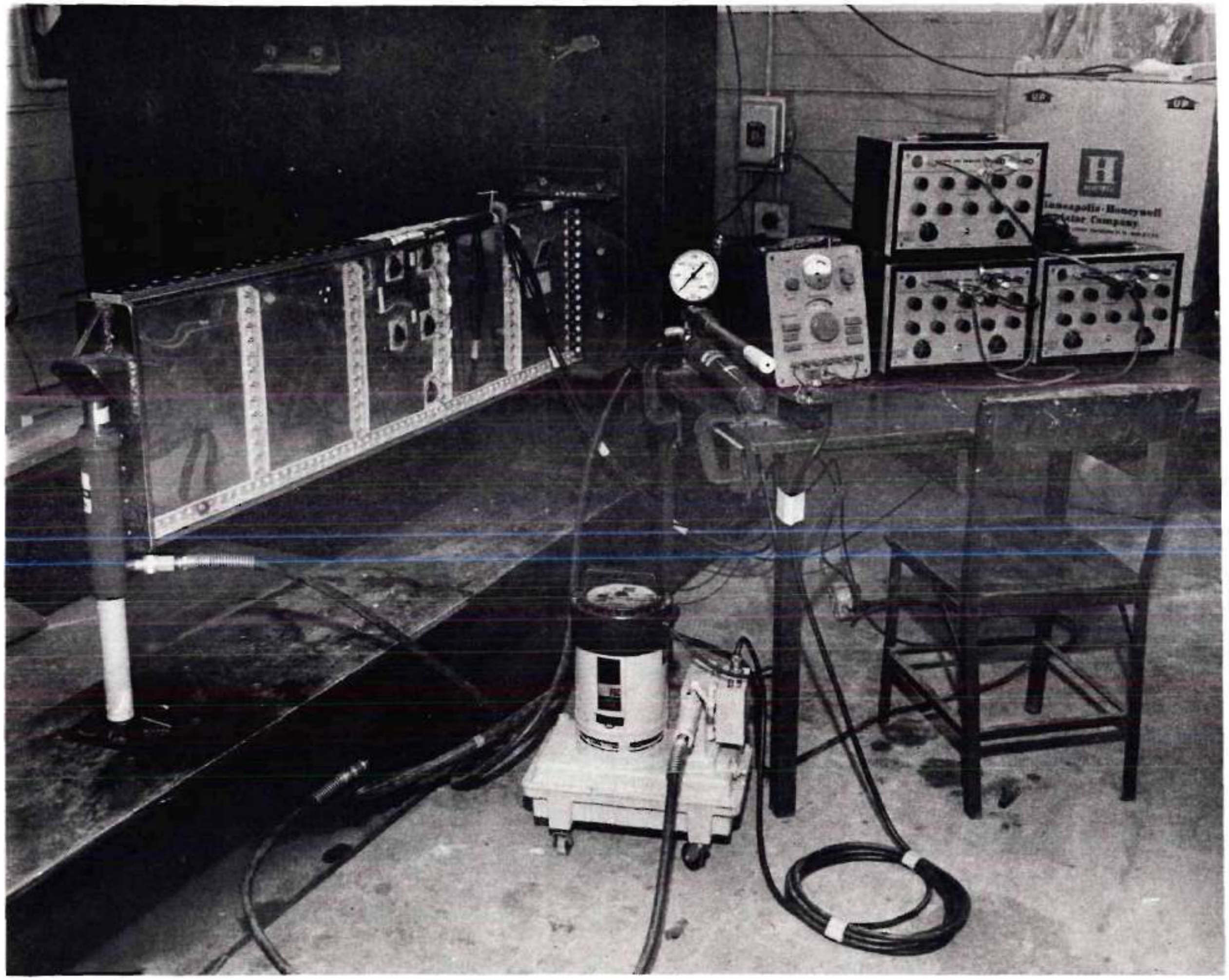


Figure 4. Entire Testing Apparatus

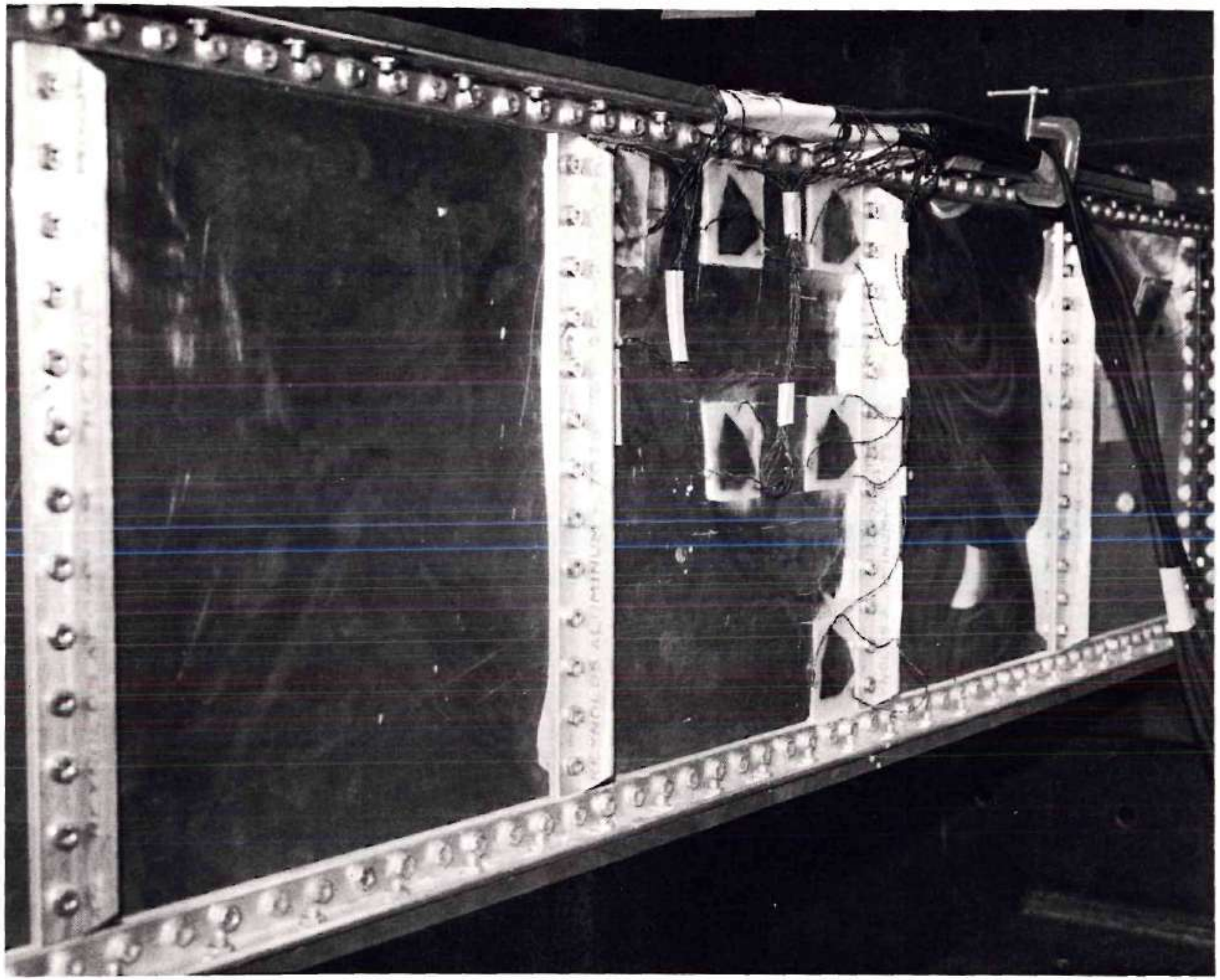


Figure 5. Web Buckles

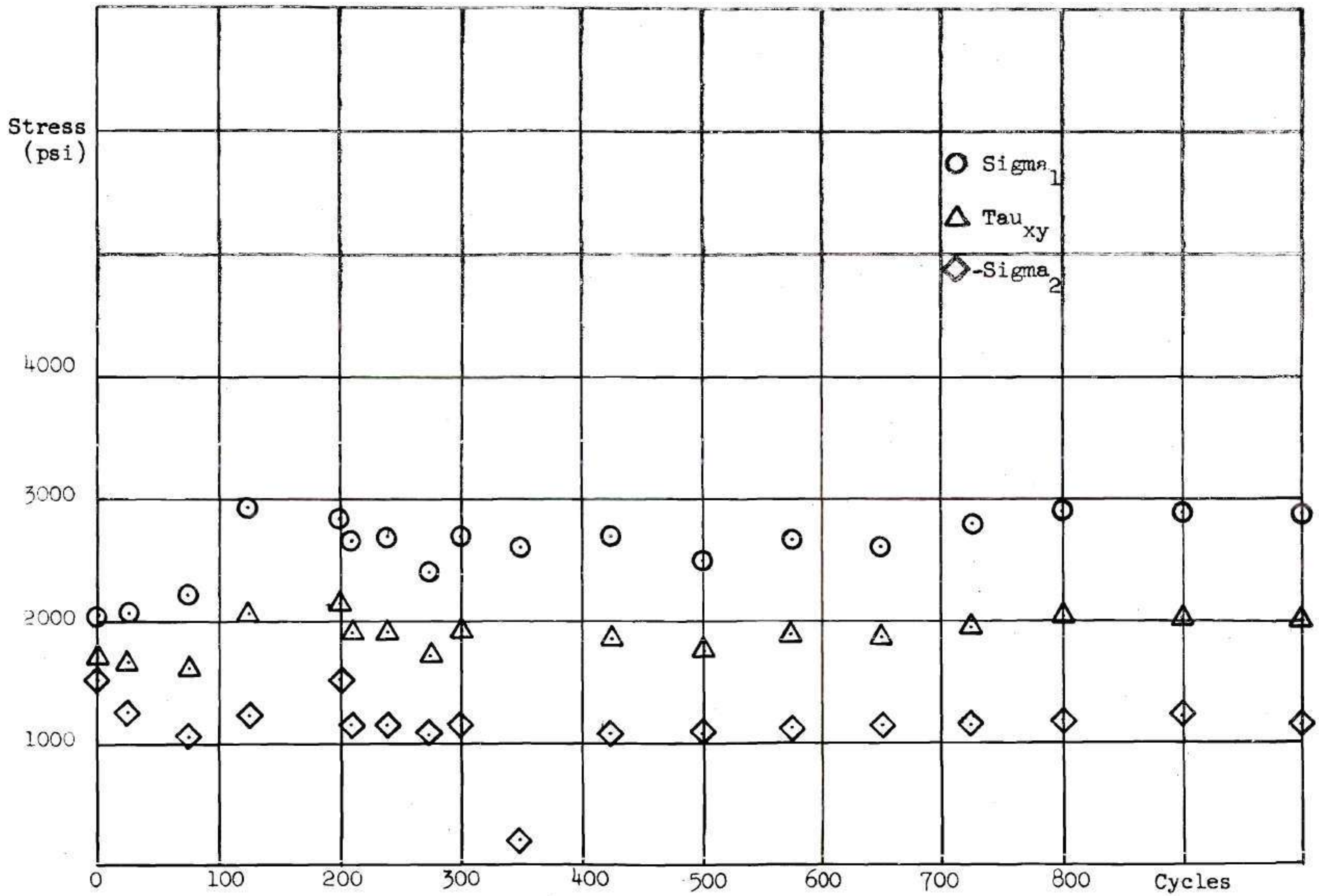


Figure 6. Stresses versus Cycles for 1000 Pound Load

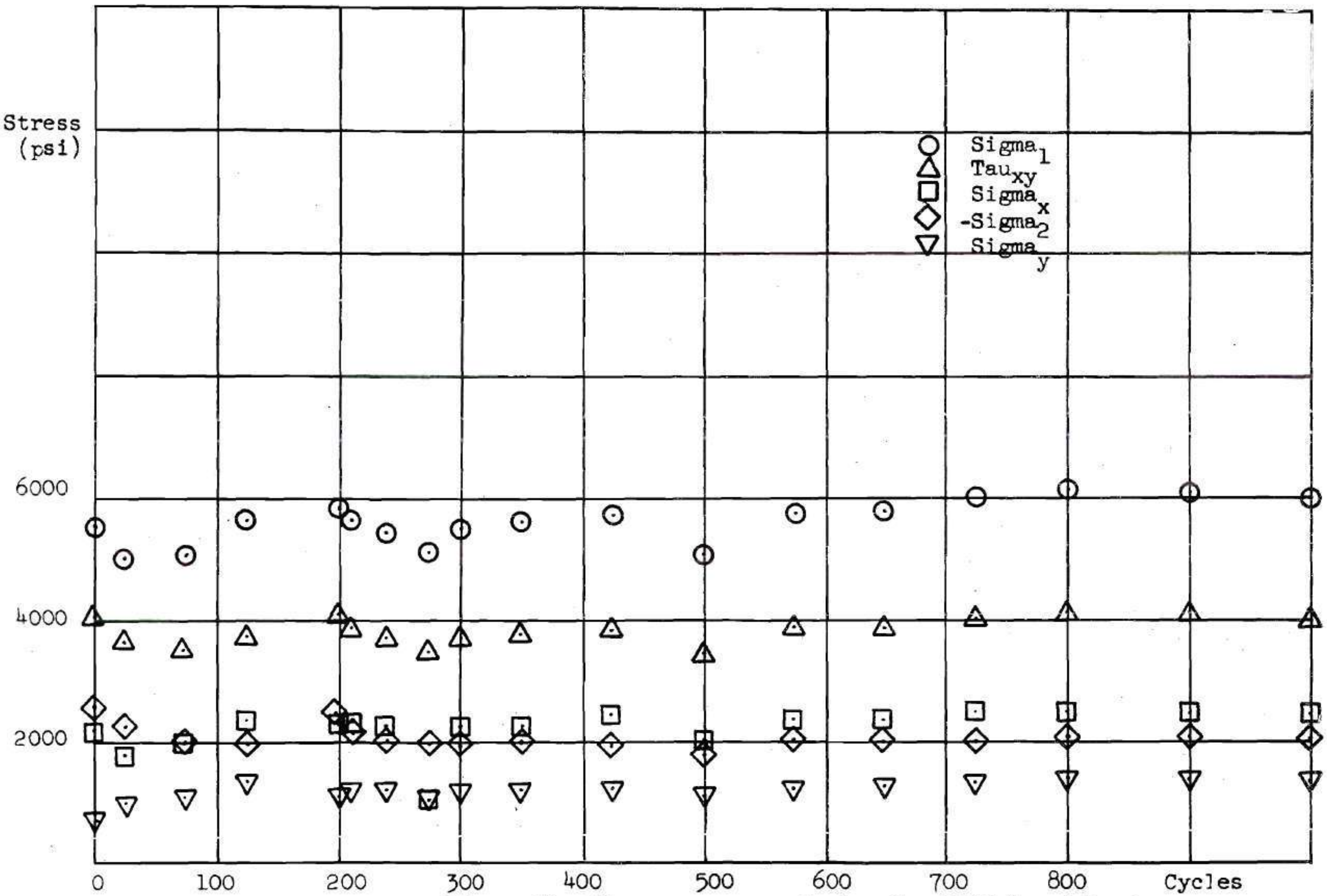


Figure 7. Stresses versus Cycles for 2000 Pound Load

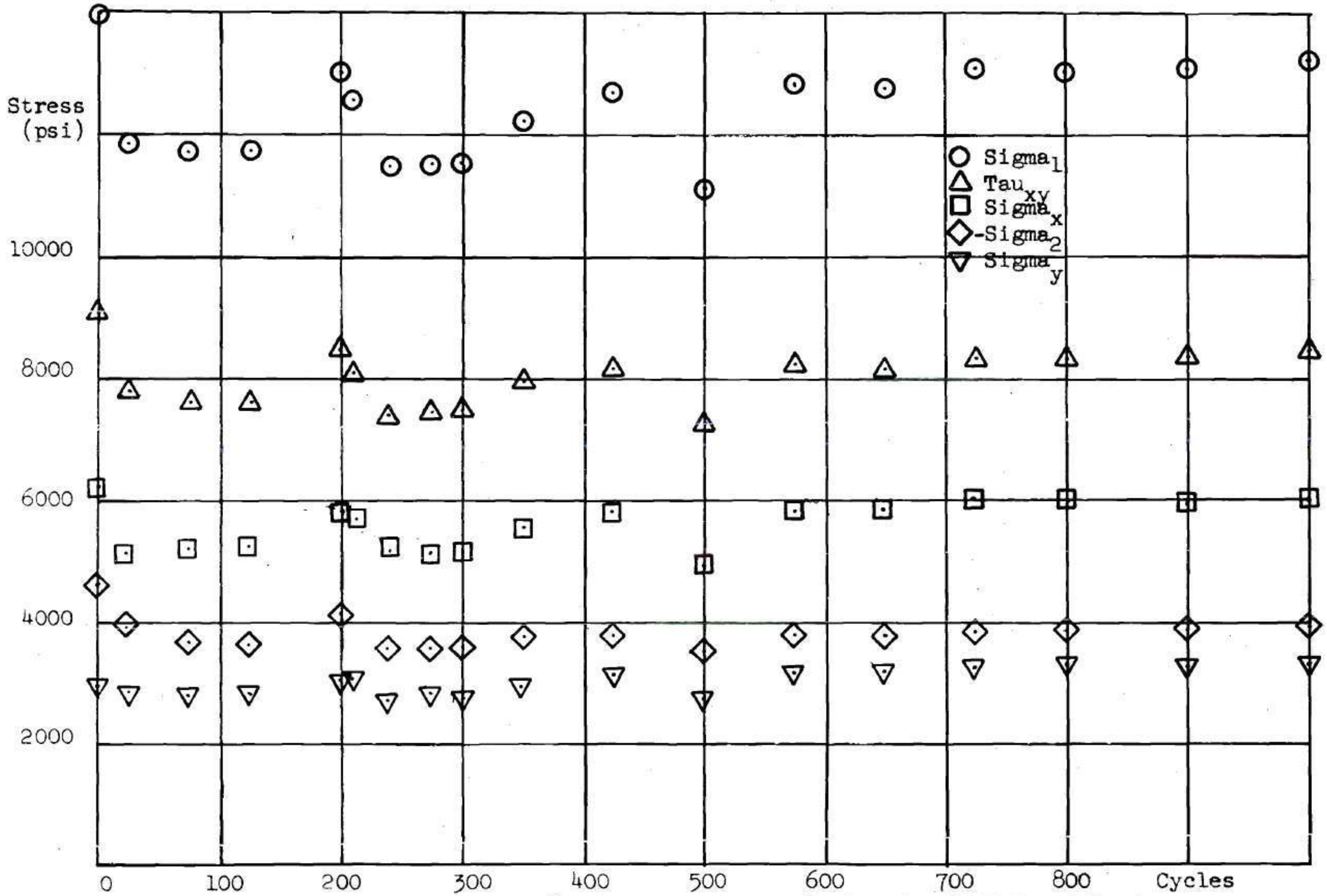


Figure 8. Stresses versus Cycles for 4000 Pound Load

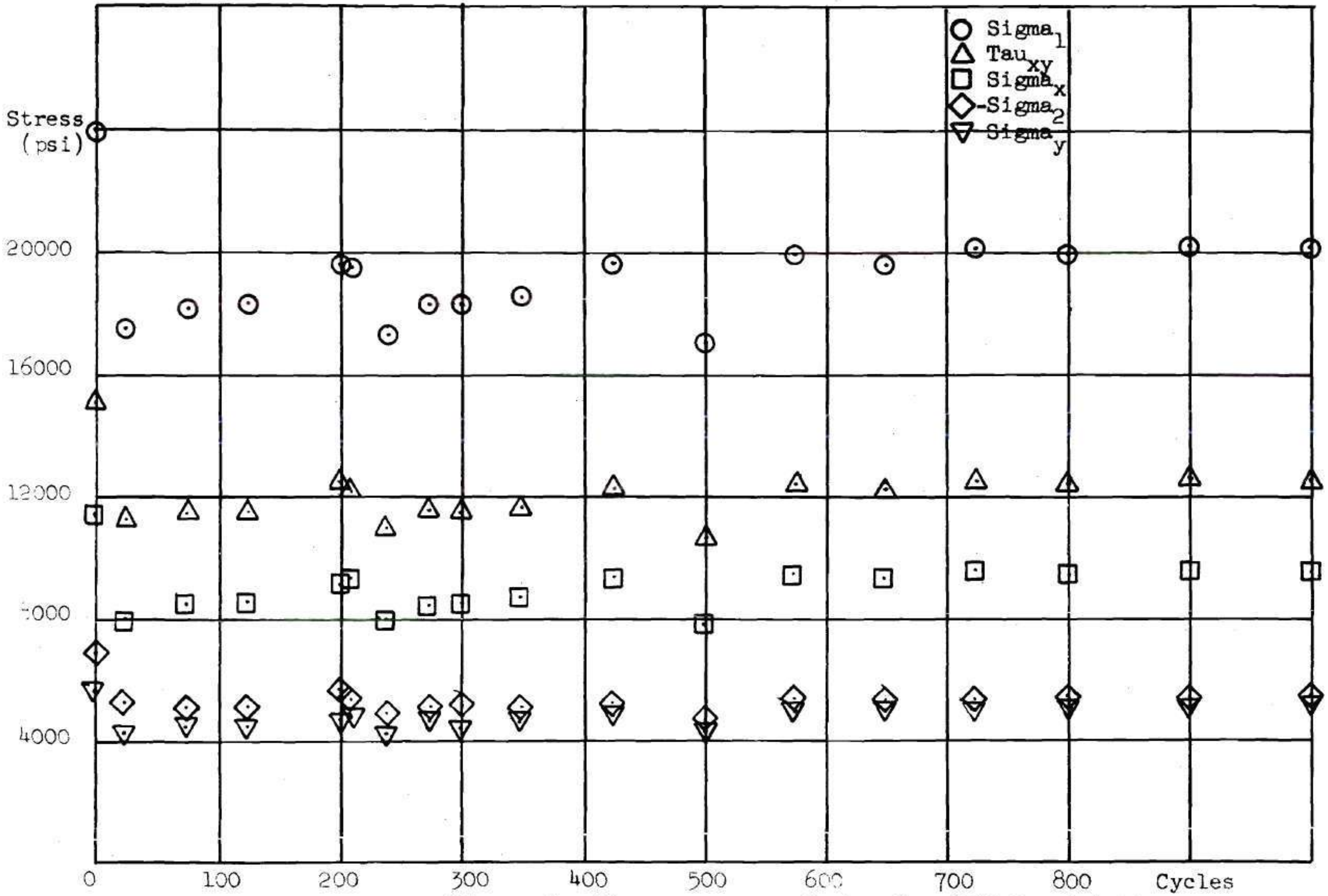


Figure 9. Stresses versus Cycles for 6000 Pound Load

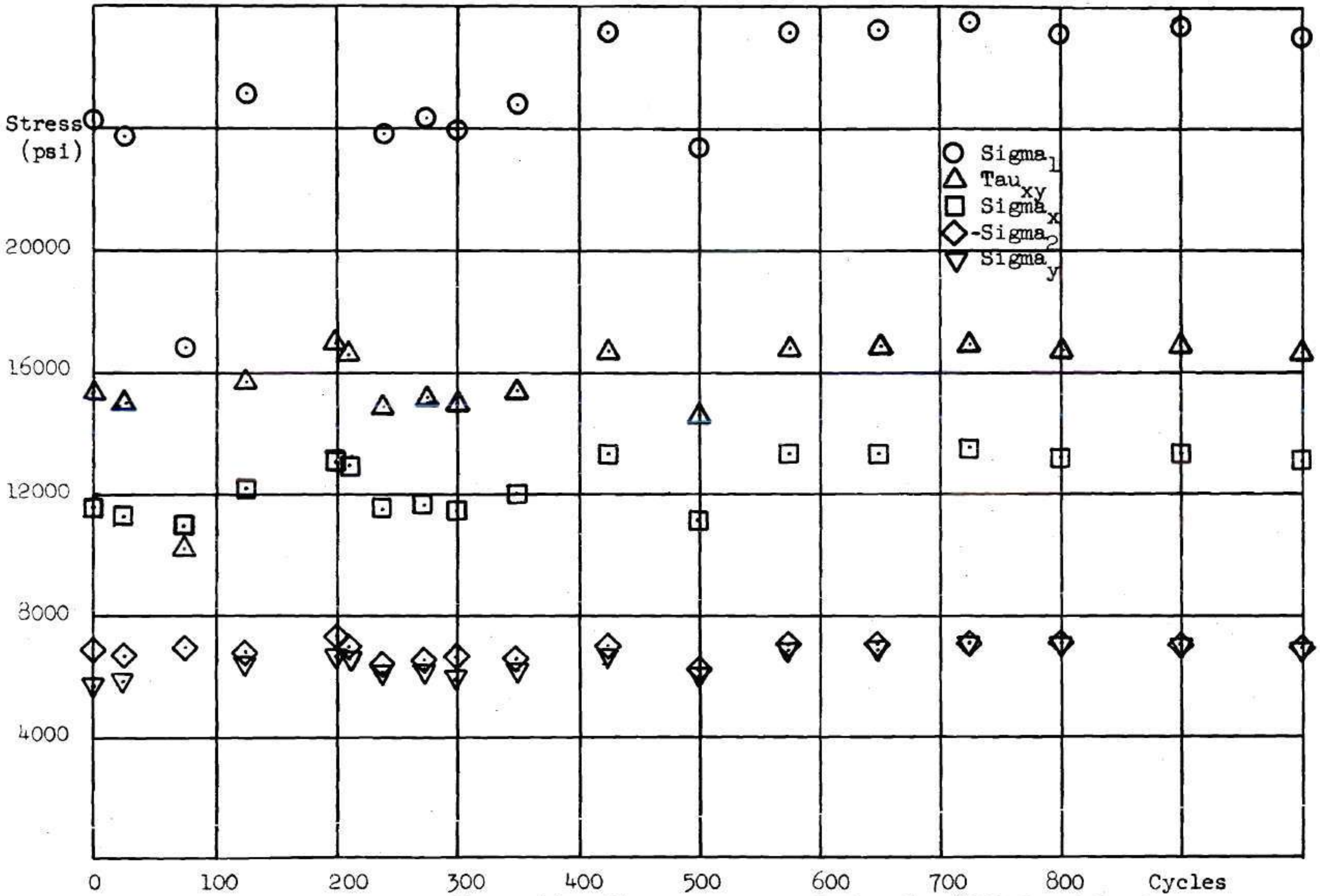


Figure 10. Stresses versus Cycles for 8000 Pound Load

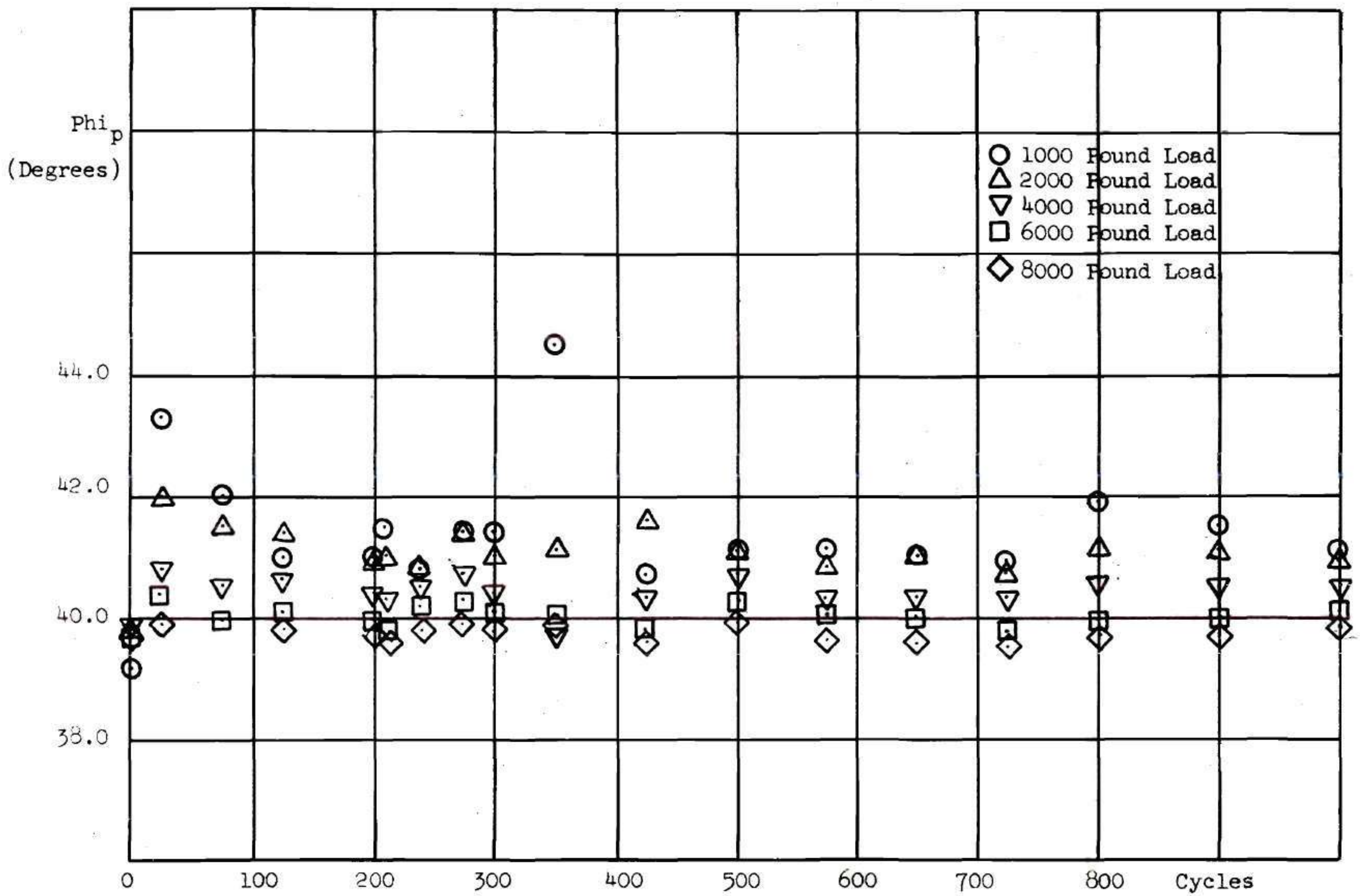


Figure 11. Angle of Principal Stress versus Cycles

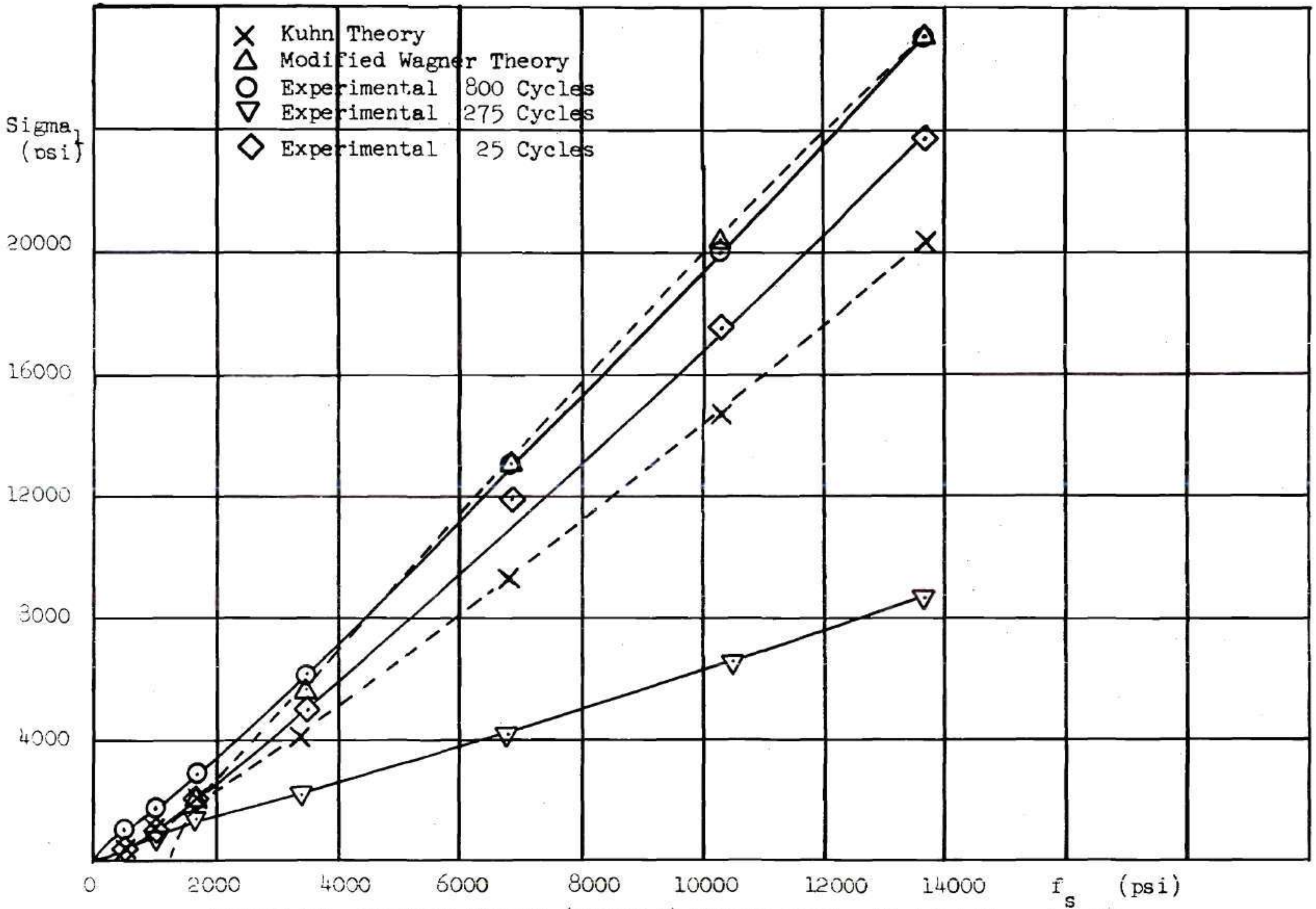


Figure 12. Maximum Normal (Tensile) Stress versus Applied Shearing Stress

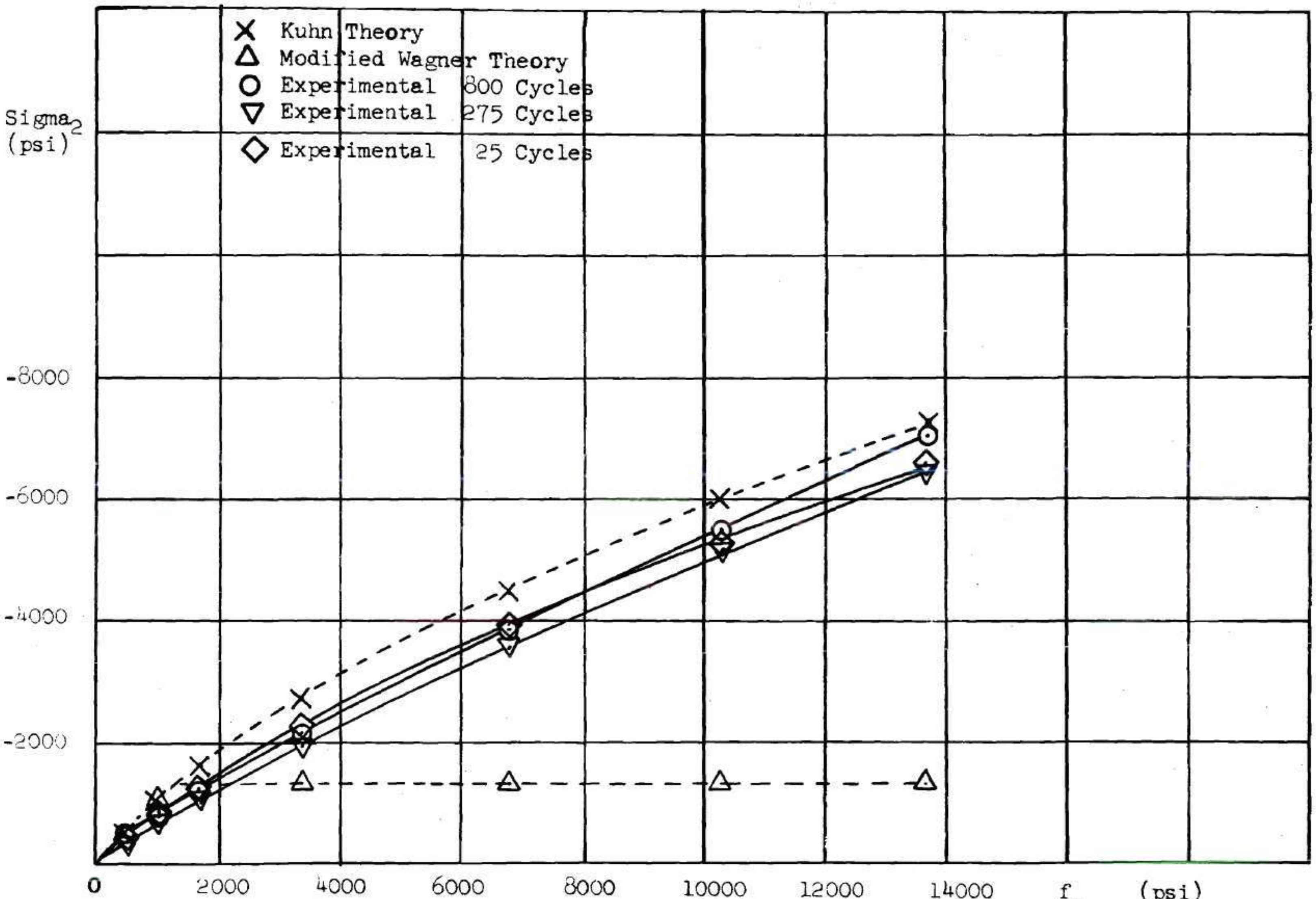


Figure 13. Minimum Normal (Compressive) Stress versus Applied Shearing Stress

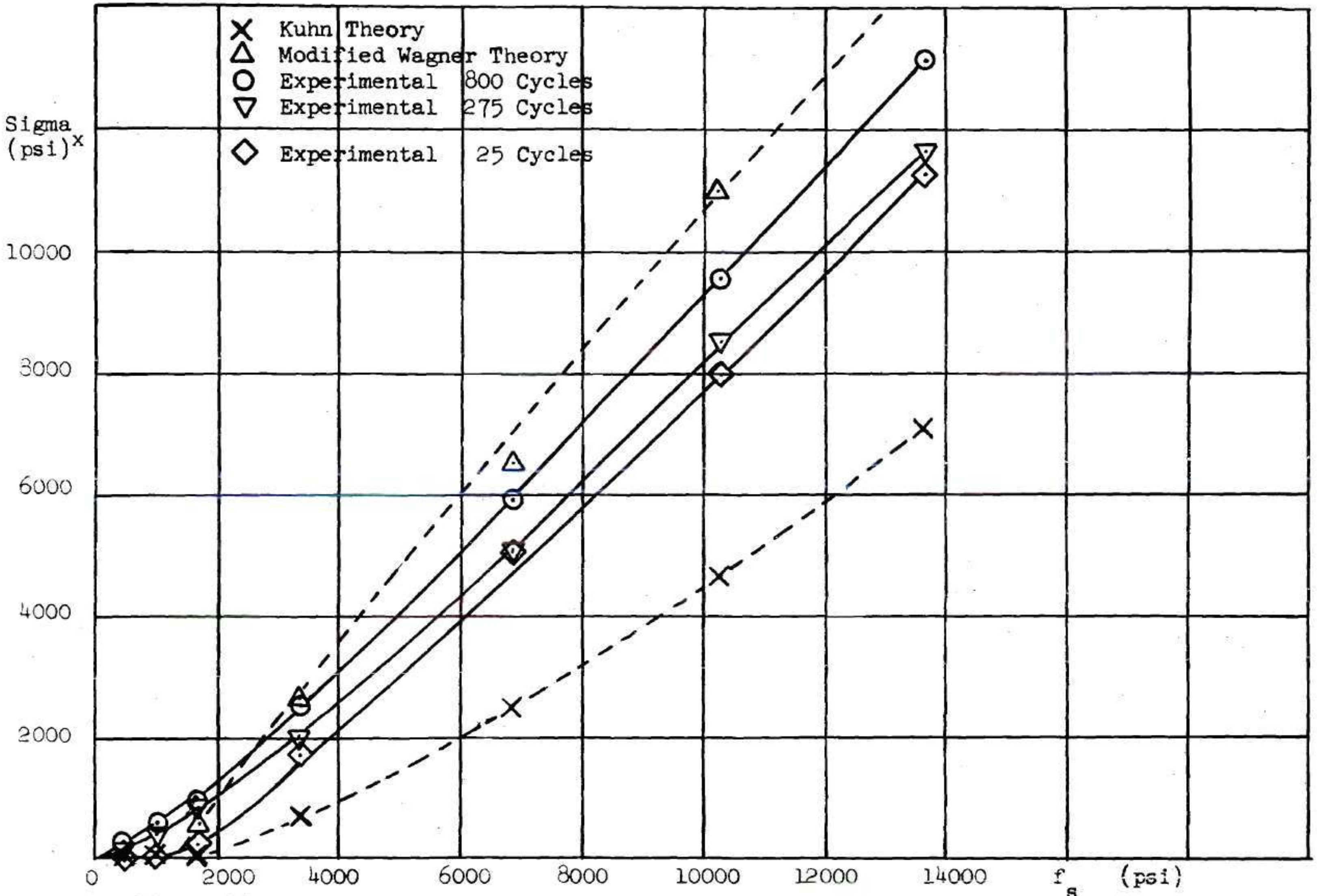


Figure 14. Component of Normal Stress in X-Direction versus Applied Shearing Stress

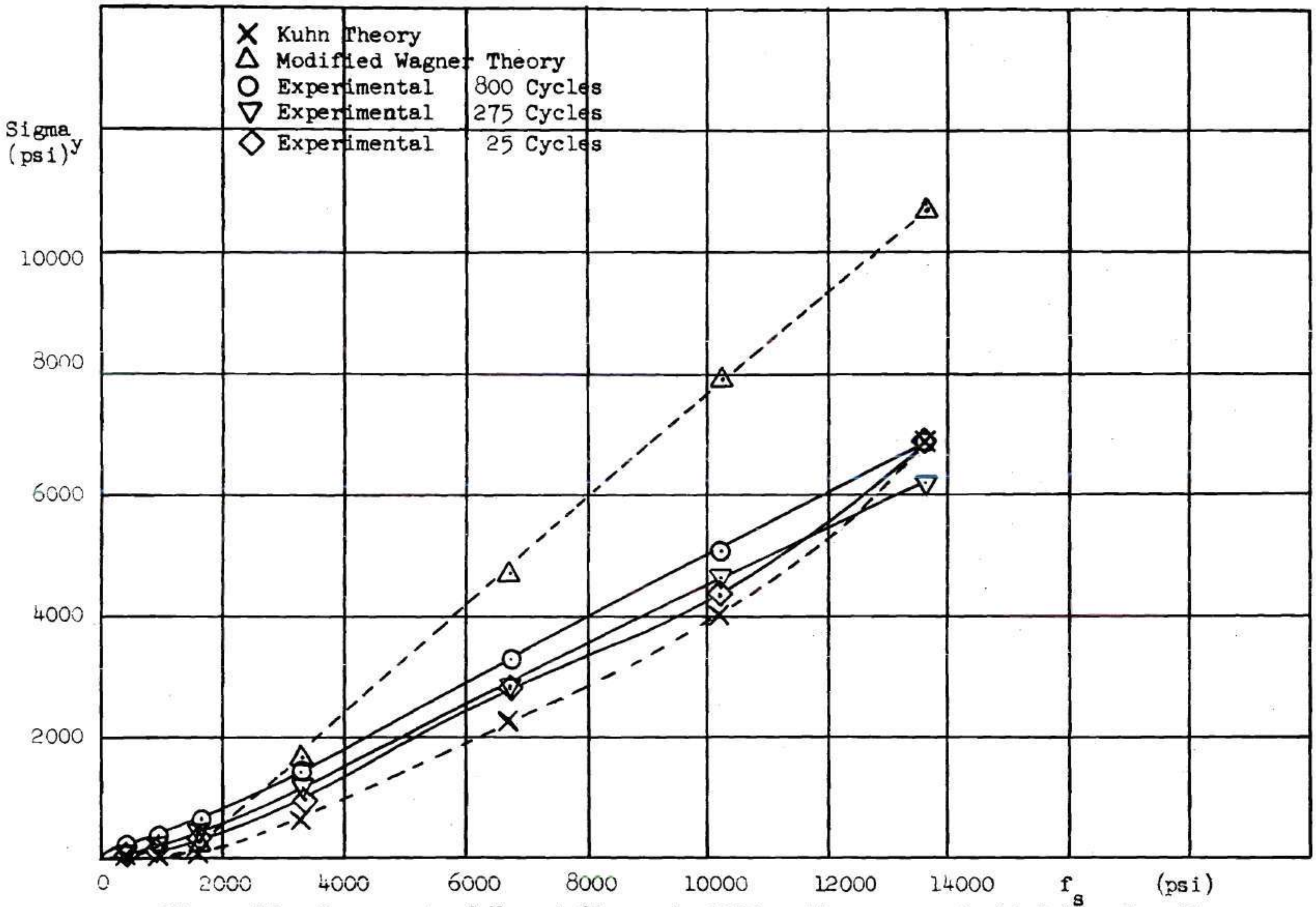


Figure 15. Component of Normal Stress in Y-Direction versus Applied Shearing Stress

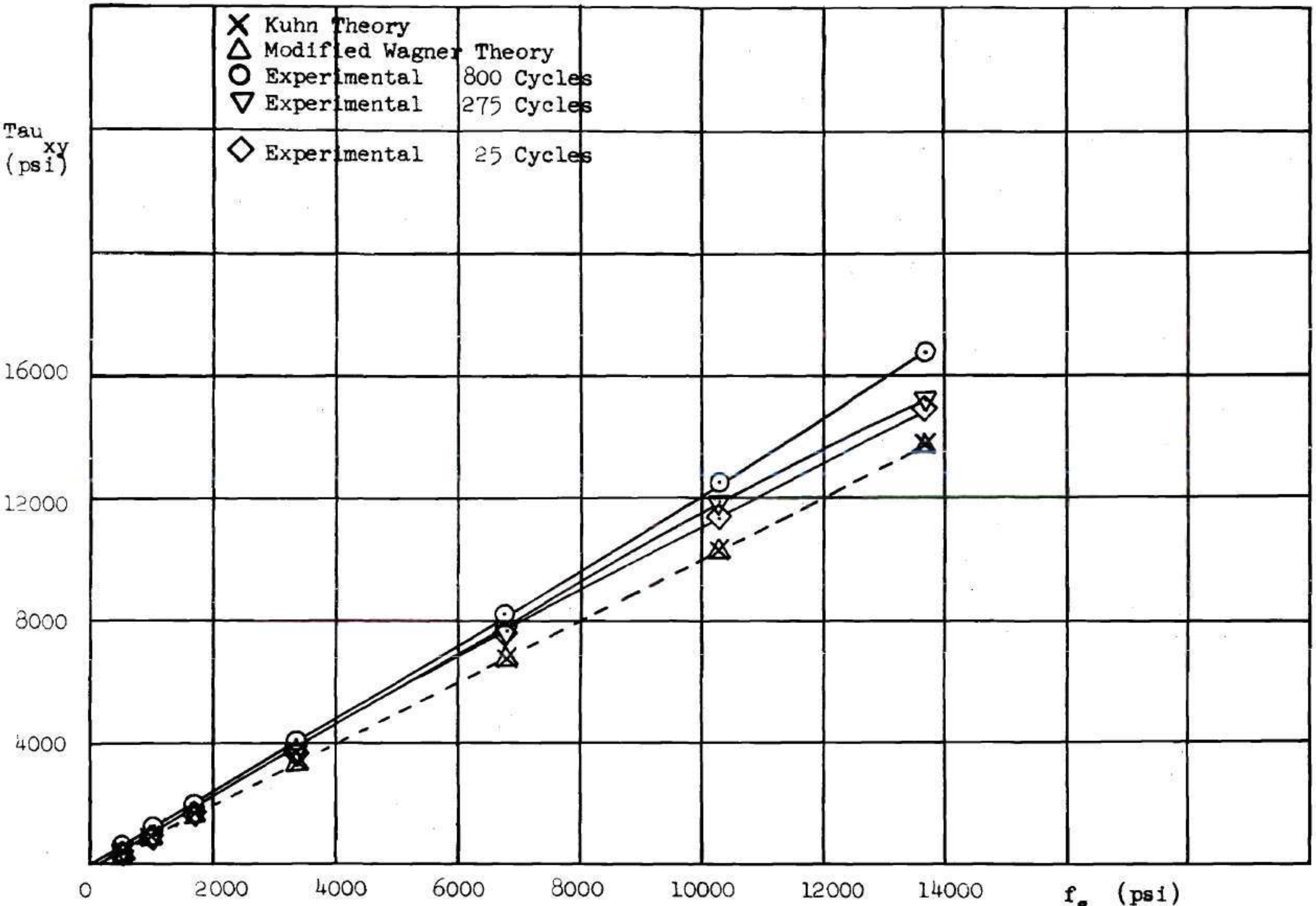


Figure 16. Web Shearing Stress versus Applied Shearing Stress

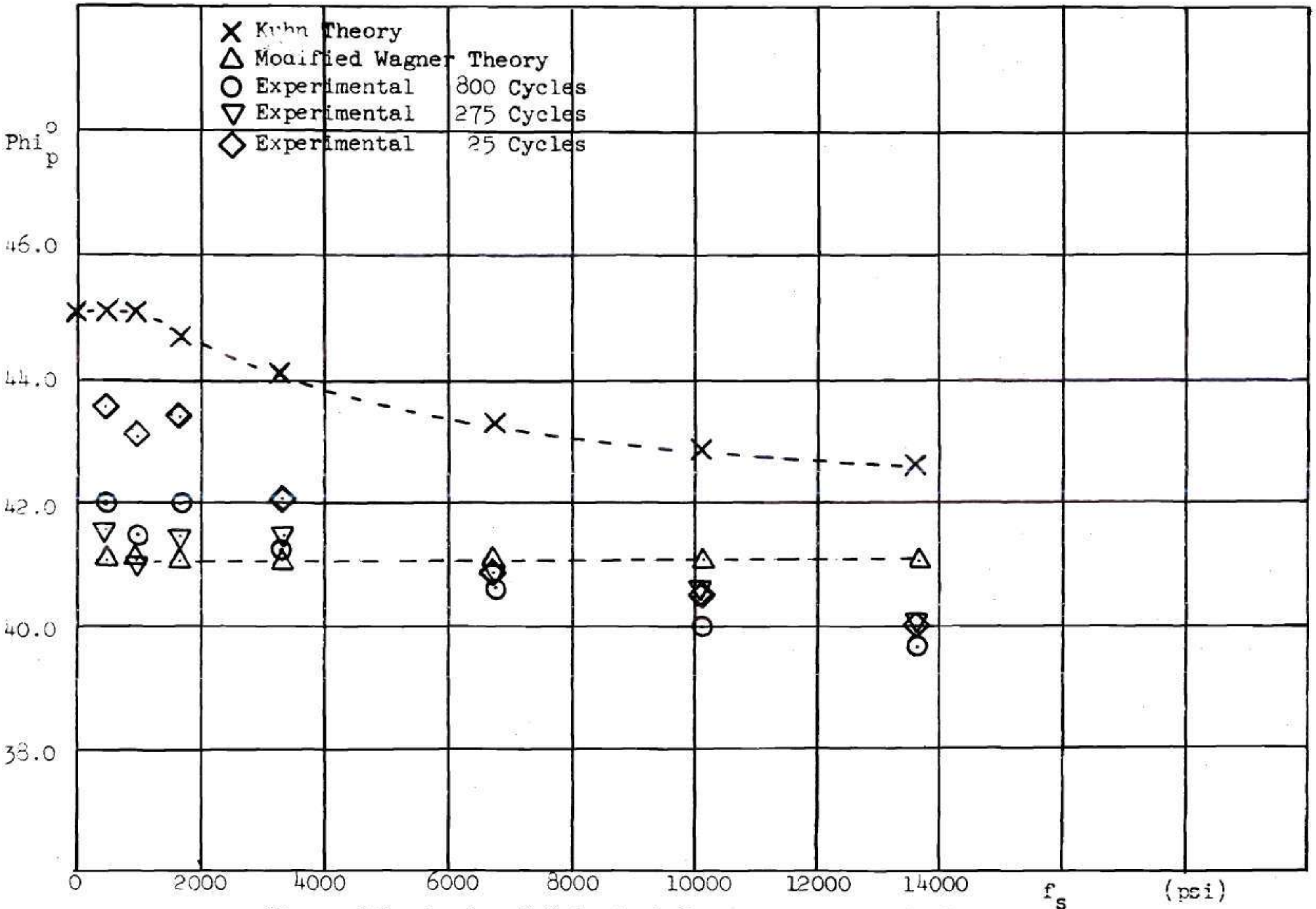


Figure 17. Angle of Principal Stress versus Applied Shearing Stress

BIBLIOGRAPHY

1. Wagner, Herbert, "Flat Sheet Metal Girders with Very Thin Metal Web. Part I - General Theories and Assumptions", National Advisory Committee for Aeronautics Technical Memorandum No. 604, 1931.

Wagner, Herbert, "Flat Sheet Metal Girders with Very Thin Metal Web. Part II - Sheet Metal Girders with Spars Resistant to Bending. Oblique Uprights-Stiffness", National Advisory Committee for Aeronautics Technical Memorandum No. 605, 1931.

Wagner, Herbert, "Flat Sheet Metal Girders with Very Thin Metal Web. Part III - Sheet Metal Girders with Spars Resistant to Bending. The Stress in Uprights-Diagonal Tension Fields", National Advisory Committee for Aeronautics Technical Memorandum No. 606, 1931.

2. Kuhn, Paul, Peterson, James P., and Levin, L. Ross, "Summary of Diagonal Tension. Part I - Methods of Analysis", National Advisory Committee for Aeronautics Technical Note No. 2661, 1952.

Kuhn, Paul, Peterson, James P., and Levin, L. Ross, "Summary of Diagonal Tension. Part II - Experimental Evidence", National Advisory Committee for Aeronautics Technical Note No. 2662, 1952.

3. Denke, Paul H., "Strain Energy Analysis of Incomplete Tension Field Web-Stiffener Combinations", Journal of the Aeronautical Sciences, Vol. 11, Number 1, January, 1944, pp. 25-40.

4. Perry, C. C., and Lissner, H. R., The Strain Gage Primer, (New York: McGraw-Hill Book Co., Inc.), 1955.

5. Ades, C. S., "Reduction of Strain Rosettes in the Plastic Range", Proceedings of the Society for Experimental Stress Analysis, Vol. XIX, Number 2, pp. 345-349.